DEPARTMENT OF ENVIRONMENT & CONSERVATION

DOE OVERSIGHT DIVISION

ENVIRONMENTAL MONITORING REPORT

JANUARY THROUGH DECEMBER 2005

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LIST OF COMMON ACRONYMS AND ABREVIATIONS

ASER	Annual Site Environmental Report (written by DOE)
ASTM	American Society for Testing and Materials
BCK	Bear Creek Kilometer (station location)
BFK	Brushy Fork Creek Kilometer (station location)
BJC	Bechtel Jacobs Company
BMAP	Biological Monitoring and Abatement Program
BNFL	British Nuclear Fuels Limited
BOD	Biological Oxygen Demand
BWXT	Y-12 Prime Contractor (current)
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAP	Citizens Advisory Panel (of LOC)
CCR	Consumer Confidence Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	Contaminants of Concern
COD	Chemical Oxygen Demand
CPM (cpm)	Counts per Minute
CRM	Clinch River Mile
CROET	Community Reuse Organization of East Tennessee
CWA	Clean Water Act
CYRTF	Coal Yard Runoff Treatment Facility (at ORNL)
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOE-O	Department of Energy-Oversight Division (TDEC)
DWS	Division of Water Supply (TDEC)
E. coli	Escherichia coli
EAC	Environmental Assistance Center (TDEC)
ED1, ED2, ED3	Economic Development Parcel 1, Parcel 2, and Parcel 3
EFPC	East Fork Poplar Creek
EMC	Environmental Monitoring and Compliance (DOE-O Program)
EMWMF	Environmental Management Waste Management Facility
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Trichoptera (May flies, Stone flies, Caddis flies)
ERAMS	Environmental Radiation Ambient Monitoring System
ET&I	Equipment Test and Inspection
ETTP	East Tennessee Technology Park
FDA	U.S. Food and Drug Administration
FFA	Federal Facility Agreement
FRMAC	Federal Radiation Monitoring and Assessment Center
g	Gram
GHK	Gum Hollow Branch Kilometer (station location)
GIS	Geographic Information Systems
GPS	Global Positioning System
GW	Ground Water
GWQC	Ground Water Quality Criteria
HAP	Hazardous Air Pollutant
HCK	Hinds Creek Kilometer (station location)
IBI	Index of Biotic Integrity
IC	In Compliance
"ISCO" Sampler	Automatic Water Sampler
IWQP	Integrated Water Quality Program
K-####	Facility at K-25 (ETTP)

LIST OF COMMON ACRONYMS AND ABREVIATIONS CONTINUED

K-25	Oak Ridge Gaseous Diffusion Plant (now called ETTP)
KBL	Knoxville Branch Laboratory
KFO	Knoxville Field Office
l	Liter
LC_{50}	Lethal Concentration at which 50 % of Test Organisms Die
LMES	Lockheed Martin Energy Systems (past DOE Contractor)
LOC	Local Oversight Committee
LWBR	Lower Watts Bar Reservoir
MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual
MBK	Mill Branch Kilometer (station location)
MCL	Maximum Contaminant Level (for drinking water)
MDC	Minimum Detectable Concentration
MEK	Melton Branch Kilometer (station location)
µg	Microgram
mg	Milligram
MIK	Mitchell Branch Kilometer (station location)
ml	Milliliter
MMES	Martin Marietta Energy Systems (past DOE Contractor)
µmho	Micro mho (mho=1/ohm)
MOU	Memorandum of Understanding
m	Meter
mR	Microroentgen
mrem	1/1000 of a rem – millirem
N, S, E, W	North, South, East, West
NAAQS	National Ambient Air Quality Standards
NAREL	National Air and Radiation Environmental Laboratory
NAT	No Acute Toxicity
NEPA	National Environmental Policy Act
NIC	Not In Compliance
NOAEC	No Observable Adverse Effect Concentration (to Tested Organisms)
NOV	Notice of Violation
NPDES	National Pollution Discharge Elimination System
NRWTF	Non-Radiological Waste Treatment Facility (at ORNL)
NT	Northern Tributary of Bear Creek in Bear Creek Valley
OMI	Operations Management International (runs utilities at ETTP under CROET)
OREIS	Oak Ridge Environmental Information System http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Association
OSL	Optically Stimulated Luminescent (Dosimeter)
OU	Operable Unit
PACE	Paper, Allied-Industrial, Chemical, and Energy Workers Union
PAM	Perimeter Air Monitor
PCB	Polychlorinated Biphenol
pCi	$1x10^{-12}$ Curie (Picocurie)
PCM	Poplar Creek Mile (station location)
pH	Proportion of Hydrogen Ions (acid vs. base)
PWSID	Potable Water Identification "number"
ppb	Parts per Billion

LIST OF COMMON ACRONYMS AND ABREVIATIONS CONTINUED

ppm	Parts per Million
ppt	Parts per Trillion
PRG	Preliminary Remediation Goals
QA	Quality Assurance
QC	Quality Control
R	Roentgen
RBP	Rapid Bioassessment Program
RCRA	Resource Conservation and Recovery Act
REM (rem)	Roentgen Equivalent Man (unit)
RER	Remediation Effectiveness Report
ROD	Record of Decision
RSE	Remedial Site Evaluation
SLF	Sanitary Landfill
SNS	Spallation Neutron Source
SOP	Standard Operating Procedure
SPOT	Sample Planning and Oversight Team (TDEC)
SS	Surface Spring
STP	Sewage Treatment Plant
SW	Surface Water
TDEC	Tennessee Department of Environment and Conservation
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluation
TLD	Thermoluminescent Dosimeter
TOA	Tennessee Oversight Agreement
TRE	Toxicity Reduction Evaluation
TRM	Tennessee River Mile
TRU	Transuranic
TSCA	Toxic Substance Control Act
TSCAI	Toxic Substance Control Act Incinerator
TSS	Total Suspended Solids
TTHM’s	Total Trihalomethanes
TVA	Tennessee Valley Authority
TWQC	Tennessee Water Quality Criteria
TWRA	Tennessee Wildlife Resources Agency
U.S.	United States
UT-Battelle	University of Tennessee-Battelle (ORNL Prime Contractor)
VOAs	Volatile Organic Analytes
VOC	Volatile Organic Compound
WCK	White Oak Creek Kilometer (station location)
WM	Waste Management
WOL	White Oak Lake
X-####	Facility at X-10 (ORNL)
X-10	Oak Ridge National Laboratory
Y-####	Facility at Y-12
Y-12	Y-12 Plant (Area Office)

Executive Summary

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) is providing a report of its independent environmental monitoring for the 2005 calendar year. The report is a series of individual reports completed by division personnel. General areas of interest organize the reports: Air Quality, Biological/Fish and Wildlife, Drinking Water, Groundwater, Radiation, Surface Water, and Sediment. An abstract is provided in each report. All supporting information and data used in the completion of these reports are available for review in the division's files.

Air Quality Monitoring

RadNet Air Monitoring (previously called ERAMS) This EPA sponsored program detected slightly elevated radionuclides in air samples taken at the Y-12 National Security Complex. It is probable these results are associated with Y-12's campaign to modernize operational facilities and tear down unneeded buildings, but the exact cause is unknown. Data for RadNet samplers at ETTP and ORNL were similar to background measurements. All radiological results for air sampling in 2005 were below Clean Air Act standards.

Perimeter Ambient Air Monitoring The perimeter air monitoring program, in conjunction with associated air monitoring programs, provides information used to assess the impact of Department of Energy activities on the local environment and public health. In the program, samples are collected biweekly from twelve air monitors stationed near the boundaries of the reservation and at a background location (i.e., Fort Loudoun Dam). Each sample is analyzed for gross alpha and gross beta radiation at the state radiochemistry laboratory. A composite sample from each location is analyzed annually for gamma emitters. Results from the perimeter monitoring stations are compared to the background measurements and environmental standards provided in the Clean Air Act. The data for 2005 did not indicate a significant impact on local air quality from activities on the reservation.

Fugitive Radiological Air Monitoring High volume air samplers are used in this program to monitor radioactive contaminants at locations where there is a potential for the release of fugitive/diffuse air emissions released on the Oak Ridge Reservation from remedial or waste management activities. During 2005, one of the samplers was stationed in Loudon County to collect background data. Another sampler was positioned to monitor waste disposal activities at the Environmental Management Waste Management Facility in Bear Creek Valley. The two remaining samplers were placed at the East Tennessee Technology Park to monitor the decontamination and demolition of contaminated facilities at the site. The results for 2005 for monitoring stations on the reservation were similar to the background values and all results where lower than screening values used to assess compliance with Clean Air Act standards (10 mrem/yr).

The Hazardous Air Pollutants (HAPs) reports for metal monitoring at Y-12, ETTP, and Oak Ridge National Laboratory (ORNL) indicate no apparent elevated concentration of metals of concern. HAPs metals monitored were arsenic, beryllium, cadmium, total chromium, lead, nickel and uranium metal. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis except for lead at ETTP and chromium at Y-12 Concentrations of lead in ambient air were comparable to thos found in previous years. The atmospheric lead concentrations were also consistent with those reported by DOE for past years. The chromium

value is consistent with historically measured values of total atmospheric chromium seen sporadically (about once per year) during past monitoring at Y-12 and ORNL.

Biological/Fish and Wildlife

Contaminants in Fish Tissue During 2003, the division proposed largemouth bass (*Micropterus salmoides*) fish tissue analysis to further substantiate collections and data used to determine local fishing advisories; since this species is a popular sport fish and past evaluations have not adequately included it. The division analyzes bass through a cooperative effort with the Tennessee Valley Authority (TVA). Largemouth bass were to be acquired from TVA at four locations around the ORR during their annual Black Bass Survey in order to compare results with action criteria. Tissue samples from these fish were then to be analyzed for contaminants of concern. Due to seasonal conditions, an insufficient number of specimens of adequate size were not obtainable. Therefore this project was not completed in 2005 but is expected to be completed in 2006.

Canada Geese On June 23 and 24, 2005, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducted oversight of the annual Canada Geese (*Branta canadensis*) monitoring project on the Oak Ridge Reservation (ORR). The objective of this study was to determine if geese are becoming contaminated on the ORR. The captured geese were transported to the Tennessee Wildlife Resources Association (TWRA) game check station on Bethel Valley Road and tested for radioactive contamination. None of the geese captured showed elevated gamma counts above the 5 pCi/g game release level. If captured geese show contamination, DOE-O will collect geese offsite. Since no contaminated geese were captured, the DOE-Oversight Division did not conduct additional offsite sampling of Canada Geese.

Aquatic Macroinvertibrates Semi-quantitative benthic macroinvertebrate samples were collected from study sites on four streams impacted by Department of Energy (DOE) operations. Using the state of Tennessee standard operating procedures for macroinvertebrate surveys, samples were collected, processed, and analyzed using applicable metrics. A score was calculated from the metrics and a stream site health rating was assigned. In general, results showed signs of biotic improvement with increasing water quality downstream of DOE influences. Only two study sites had a stream rating as healthy as bioregion reference conditions. Two additional stream sites were sampled this year for qualitative purposes. Continued benthic macroinvertebrate monitoring would more closely define impacts on the aquatic environment from DOE related activities. Assessments of DOE remedial activities and cleanup efforts can also be made from these data.

Invasive plant mapping of a Black Oak Ridge Conservation Easement was started to get a handle on the ecological health and possible future management needs. From this initial mapping effort, the division observed that the majority of the exotic species occur along existing gravel roads, pine-beetle damaged pine plantations, and formerly disturbed sites. Here, the exotics have little competition for habitat space. However, in the case of Kudzu infestations, competition from native plants does not seem to matter as this aggressive invader takes over all vegetation (living or dead), open space, etc. There are even infested locations in the backcountry away from roads or trails.

Vascular Plant Surveys Vascular plant surveys and oversight of DOE botanical fieldwork was conducted by the division in 2005. Survey sites included wetlands, ORR site access roads (to be widened as fire-breaks), the new waste haul road in west Bear Creek Valley and the Black Oak Ridge Conservation Easement (BORCE) site near East Tennessee Technology Park. Priority was given to locating rare plants and documentation of pest plant invasion areas on the ORR. Division staff also provided botanical support to the TDEC Division of Natural Heritage programs (DNH) including the rare plant program, the natural areas program, and the inventory program. New, rare plant locations (previously unrecorded) were identified and mapped on the ORR during 2005 and were documented with DNH.

Diatom Community Response The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division), Environmental Monitoring Section, reinstated monitoring of diatom communities in Oak Ridge Reservation (ORR) watersheds during 2005. Communities of attached benthic algae (periphyton) react with individual tolerance to anthropogenic stress (e.g., elevated metals concentrations), and provide a good analysis for identifying stressed water quality. Thus, water quality can be characterized by evaluating the results of qualitative and quantitative measurements of the algal community. Benthic algae was collected using artificial substrates on a monthly rotation for seven months (May-December) in Bear Creek, East Fork Poplar Creek, Melton Branch, White Oak Creek, and four reference streams to test the water quality and ecological recovery of these aquatic systems impacted by upstream Department of Energy (DOE) operations. Results from ten periphyton monitoring sites were compared to their respective reference streams located in the same watershed or geomorphologic province as the associated test sites. Diatoms and non-diatom taxa were keyed-out to the generic level (including some identifications to the species level). Results of the 2005 monitoring suggest a general trend of increasing diatom diversity with distance from the DOE source of contamination. The results for the White Oak Creek and Melton Branch sites, which currently are undergoing massive environmental cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), remain unclear at this time.

Drinking Water

Chlorine Residuals The monitoring activities through oversight and independent sampling of the sanitary water distribution systems on the ORR met the regulatory requirement of 0.2 mg/L for residual chlorine. No elevated levels of bacteria above the regulatory limits were reported.

The RadNet Drinking Water Program (previously called ERAMS) Samples from the five local drinking water treatment plants monitored in this program indicate that radionuclides were well below regulatory criteria. As in the past, tritium was found in higher concentrations at the Gallaher Water Treatment Plant than the four other systems monitored in the program. The Gallaher Plant is the first facility downstream of White Oak Creek, the major source of radionuclides entering the Clinch River from the reservation.

Oak Ridge Reservation Potable Water Distribution Systems The scope of TDEC DOE-O's independent sampling includes oversight of potable water quality on or impacted by the ORR. TDEC conducted oversight of backflow prevention devices and sanitary surveys at ORR facilities. As the three Department of Energy (DOE) Oak Ridge Reservation (ORR) plants become more accessible to the public, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) has expanded its oversight of the DOE facilities' safe drinking water programs. The results of these inspections revealed that the three reservation systems provide water that meets State regulatory levels. The distribution system at Y-12 does have some deficiencies in their Cross Connection Control Program, as noted in the sanitary survey.

Groundwater

Springs and Residential Wells The calendar year 2005 groundwater-sampling projects included forty seven (47) exit pathway springs and four (4) surface water sites integrated with groundwater. Residential wells are to be sampled on a request basis only starting this sampling year. Six residential well sites were sampled during 2005. Residential well sampling saw a tritium indication in one well, RWA 74. The well water showed tritium activity measured at 409 pCi/L with a calculated error of 188 pCi/L. While this result has not been replicated (domestic wells generally being sampled annually) the reported MDA and error suggests that tritium has been detected in this well. No other radiochemicals other than the generally expected daughter products of naturally occurring radon and uranium have been detected in samples obtained from this well. Residential water sources will be monitored for the presence of DOE related nuclear isotopes. Residential wells in the past have showed no evidence of contamination. Exit pathway springs in the peripheral areas of the Oak Ridge Reservation were monitored for determination of quality and effectiveness of DOE's monitoring and surveillance programs. One offsite spring near ETTP and a spring offsite of Y-12 showed volatile organic contamination beyond mapped plume boundaries. An important addendum to this report is the discovery by division personnel that the protective gloves utilized in collecting environmental samples has been responsible for false positives for the volatile organic solvent carbon disulfide. A separate report on this investigation appears in the appendix.

Radiation

Ambient Radiation The Tennessee Department of Environment and Conservation began monitoring ambient radiation levels on the Oak Ridge Reservation in 1995. This program provides estimates of the dose to members of the public from exposure to gamma and neutron radiation attributable to Department of Energy activities on the reservation and baseline values for measuring the need and effectiveness of remedial activities. In this effort, environmental dosimeters have been placed at selected locations on and near the reservation. Results from the dosimeters are compared to background values and the state dose limit for members of the public. All the doses reported in 2005 for off-site locations were below the dose limit for members of the public. Several locations on the ORR considered to be potentially accessible to the public had results in excess of the limit, but there was an overall decrease in the number of these locations and magnitude of the doses reported, compared to pervious years. This decrease can largely be attributed to the removal of UF_6 cylinders stored at ETTP. As in the past, doses above the 100 mrem/yr limit were relatively common at locations located in access restricted areas of the reservation.

Real Time Gamma Radiation The division maintained gamma exposure rate monitors at a background location (Fort Loudoun Dam), MSRE (ORNL), Y-12's Industrial Landfill, the Molten Salt Reactor, and the Environmental Management Waste Management Facility (Bear Creek Valley). Measurements collected from these sites ranged from 6 μrem/hr to 475 μrem/hr. The highest exposure rates were recorded at the Environmental Management Waste Management Facility during the delivery of waste from ORNL's Homogeneous Reactor Retention Basin and ETTP's K-770 Scrap Yard. All of the results were below state and Nuclear Regulatory Commission regulations that require their licensees to conduct operations in such a manner that the external dose in any unrestricted area not exceed 2.0 mrem (approximately 2000 μrem) in any one-hour period.

Bioaccumulation of Radionuclides in Aquatic Vegetation The purpose of this study was to determine if contaminated groundwater emerging from springs on the ORR was impacting aquatic plant species. The data suggest this is the case and that a correlation exists between the concentrations of radionuclides found in groundwater and aquatic vegetation from the same monitoring locations. The project has implications relative to both human and wildlife exposures.

Facility Surveys Like other Department of Energy research facilities across the nation, the Oak Ridge Reservation released large quantities of chemical and radiological contamination into the surrounding environment during nearly five decades of nuclear weapons research and development. In response to this history, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the division) developed a Facility Survey Program to document the histories of facilities on the Reservation. The Program looks at facilities' physical condition, inventories of hazardous chemical and radioactive materials, process history, levels of contamination, and present-day potential for release of contaminants to the environment under varying conditions ranging from catastrophic (i.e. tornado) to normal everyday working situations. This broad-based assessment supports the objectives of Section 1.2.3 of the *Tennessee Oversight Agreement,* which was designed to inform local citizens and governments of the historic and present-day character of all operations on the Reservation. This information is also essential for local emergency planning purposes. Since 1994 the division's survey team has characterized 176 facilities and found that thirty five percent pose a relatively high potential for release of contaminants to the environment. In many cases, this high-potential-for-release relates to legacy contamination that escaped facilities through degraded infrastructures over decades of continual industrial use (e.g. leaking underground waste lines, substandard sumps and tanks, or ventilation ductwork). Since the inception of the program, DOE corrective actions (including demolitions) have removed nineteen facilities from the division's list of "high" Potential Environmental Release (PER) facilities.

Beginning in 2002 the Facility Survey Program staff also began organized document reviews and visits to facilities that were targeted for demolition at the ORNL and Y-12. This activity was in response to formal, accelerated infrastructure reduction (demolition) programs at each of those sites. During 2005, staff made 380 visits before, during and after the demolition of 27 facilities.

Follow-up on Needed Maintenance Actions on Otherwise Clean Areas The Oak Ridge Reservation (ORR) was placed on the National Priorities List (NPL) in 1989. The purpose of Footprint Reduction was to identify portions of the ORR that have not been environmentally impacted by past federal (Department of Energy – DOE) activities. The mission was to determine which land parcels could be conditionally released from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. CERCLA 120-(h) was used as the guideline by the footprint team for the footprint investigations.

The goal was further identified as reducing the size and configuration of the area of the ORR designated as part of the NPL site and determining a No Further Investigation (NFI) status. The land parcels were assigned numerical identifiers ranging from 1 through 20. The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) performed a radiological walkover and reconnaissance survey of each parcel and adjacent land. The investigation focused on identifying potential anthropogenic sources of contamination and exit pathway releases on the ORR, which could render the parcel(s) unfit for release. In summation, the division investigated 21,439 acres of ORR land during the footprint project. In performance of the field investigation work, certain maintenance action items were identified on the various land parcels, i.e., "study areas" (see Appendix I). The division clearly emphasized these concerns to DOE in each footprint study area report released to the public. This current project was to revisit these sites to determine if action had in fact been taken by DOE to rectify the problems and other division concerns. Official site visits were not performed as a routine manner for calendar year 2005. Instead spot checks were made during work on other projects. Unfortunately, due to budgetary cut-backs or prioritization changes on DOE's part, none of the maintenance action sites except for the SWMUs have received the requested attention or response.

Surplus Material Verifications A total of 13 radiological free release inspections were conducted at two of the three Oak Ridge Reservation (ORR) facilities. Those inspections were conducted at Y-12 and ORNL surplus sales prior to public auctions. No sales were conducted at the ETTP. Two items were removed from sales at ORNL during the year for further evaluation as a result of this program. Two observations requiring further evaluation were made at the Y-12 Surplus Sales during 2005.

UF_6 Cylinder Transportation Oversight A total of 2,708 UF_6 cylinders were shipped to Portsmouth Ohio from the East Tennessee Technology Park during calendar year 2005. Division staff members participated in monthly tri-state conference calls with representatives from Ohio and Kentucky. Numerous site visits were conducted throughout the year to observe operations, evaluate shipping over-pack containers, and evaluate related operations.

This program is supplemented by the use of Optically Stimulated Luminescent dosimeters (OSLs). These OSLs are used to monitor radiation levels around the cylinder yards and track radiation level changes as the cylinders are moved around the yards during sorting and inspection operations. The OSLs are also used to confirm that radiation levels have declined after removal of the cylinders.

Surface Water

General ambient surface water analysis is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. The DOE Oversight Division conducted sampling at 21 sites in 2005. The samples were analyzed for standard water quality parameters.

Based on comparisons with the Tennessee Water Quality Criteria (TWQC) for recreation, none of the sites exceeded these criteria. It should be recognized that sites very close to or within contaminated burial areas were not part of this scope. Specialized surface water investigations aid in evaluating point and non-point sources.

Rain Event Surface Water Monitoring

Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for contamination to impact surface waters on the ORR during excessive rain events. These events could cause the displacement of contamination that would not normally impact streams around the ORR. To assess the degree of surface water impact caused by these rain events, a sampling of streams will be conducted following heavy rain events to determine the presence or absence of contaminants of concern.

Samples were collected at six sites on the Oak Ridge Reservation (ORR) in 2005 once per quarter following a qualifying rain event. Most results were consistent with results following a heavy rain, such as high bacteriological and dissolved residue results. One exception was elevated radiological results from Melton Branch. Results here were elevated due to remedial activities taking place in Melton Valley. Although radiological analytes were seen with relatively elevated numbers, the concentrations in White Oak Creek at the White Oak Dam were not above regulatory limits. The results of the follow-up sampling on Melton Branch indicate that there was a short term insult to the stream in relation to remediation activities, but that completion of construction activities have resulted in a reduction of these levels to a point that is consistent with contaminant levels occurring prior to remedial efforts.

Physical Parameters of Surface Water Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for this pollution to impact surface waters on the ORR as well as offsite aquatic systems. The local karst topography and related structural geology influences the fate and transport of contaminants that may further degrade the groundwater and surface water quality of aquatic systems adjacent to the ORR. The division collected ambient water quality data at seven ORR and offsite stream locations during 2005. The field data results, met all state water quality criteria for the parameters observed at the seven monitoring stations. However, consistently high conductivity readings observed at Bear Creek km 12.3 (BCK 12.3) suggests degraded water quality due to high nutrients in the aquatic system. BCK 12.3 is located downstream and west of the capped S-3 Ponds site and the Y-12 West End water treatment facility.

Sediment

Sediment analysis is a key component of environmental quality and impact assessment for aquatic ecosystems. The DOE Oversight Division (DOE-O) conducted sediment sampling at 23 sites in 2005. The sediments were analyzed for inorganics, organics, and radiological parameters. Since there are no federal or state sediment cleanup levels, the data were compared to the Department of Energy’s (DOE) Preliminary Remediation Goals (PRGs) for use at the Department of Energy Oak Ridge Operations Office. Based on the designation of the water bodies involved, the values were compared to the recreational PRGs. Under recreational land use, individuals are assumed to be exposed to contaminated media while playing, fishing, hunting, or engaging in other outdoor activities. Exposure could result from ingestion of soil or sediment, inhalation of vapors from soil or sediment, dermal contact with soil or sediment, external exposure to ionizing radiation emitted from contaminants in soil or sediment, and consumption of fish. For the contaminants that were analyzed, the sediments showed no levels of concern for human health. These samples were taken under ambient conditions and not near or within contaminated burial grounds.

Bacteria Levels of East Fork Poplar Creek

East Fork Poplar Creek (EFPC) is currently posted by the state's Division of Water Pollution Control with a bacteriological advisory mandating no water contact. Although in recent years the Y-12 National Security Complex has upgraded its sanitary wastewater treatment system, public health concerns remain that effluent from Y-12 might impact surface water bacteriological levels in the creek. From July 19, 2005, to August 17, 2005, DOE-O personnel collected water samples from ten sites along EFPC. Sampling results for E. coli found that nine sites located directly on EFPC complied with state criteria for recreational water use. However, had the state adopted equivalent criteria for enterococci, none of the sampling sites would have been in compliance. Sampling results both for E. coli and enterococci suggest that relative to other locations on or near EFPC, the Y-12 Plant is not a significant source of bacterial contamination levels in the creek.

Conclusion

The 2005 monitoring results showed effort by DOE to improve the overall health of the public and the environment. Many of the pollutant anomalies measured were a result of remediation activities and resulting fugitive emissions. However, none of these resulted in an unacceptable risk to the public. The state recognizes that some releases are inevitable when environmental clean up is done. The overall benefit of cleanup out weighs the short-term negative impacts. There are still significant source terms of contaminants that could be released through failure of engineering and administrative controls. Additionally, sources of gamma radiation exposure still exist that must be effectively isolated from the public. It is necessary and prudent for the state and DOE to continue monitoring efforts to detect and evaluate as early as possible, potential releases and radiation that could affect the public.

Introduction

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) in accordance with the Tennessee Oversight Agreement Attachment A.7.2.2, is providing an annual environmental monitoring report of the results of its monitoring and analysis activities during the calendar year of 2005 for public distribution. The division was established in 1991 to administer the Tennessee Oversight Agreement and the CERCLA required Federal Facility Agreement. These agreements are designed to assure the citizens of Tennessee that the Department of Energy (DOE) is protecting their health, safety, and environment through existing programs and substantial new commitments.

This report consists of a series of individual reports that involve independent environmental monitoring by the division. The individual reports are organized by general areas of interest: Air Quality; Biological/Fish and Wildlife; Drinking Water; Groundwater; Radiation and Surface Water. Abstracts and conclusions are available in each report to provide a quick overview of the content and outcome of each monitoring effort. All supporting information and data used in the completion of these reports are available for review in the division's program files. Overall, this report characterizes and evaluates the chemical and radiological emissions in the air, water, and sediments both on and off the Oak Ridge Reservation (ORR).

The division has considered the location, environmental setting, history, and on-going DOE operations in its environmental monitoring programs. The information gathered provides information for a better understanding of the fate and transport of contaminants released from the Oak Ridge Reservation into the environment. This understanding has led to the development of an ambient monitoring system and increased the probability of detecting releases in the event that institutional controls on the Oak Ridge Reservation fail.

Currently, the division's monitoring activities have not detected any imminent threats to public health or the environment outside of the Oak Ridge Reservation. Unacceptable releases of contaminants from past DOE operational and disposal activities continue to pose risk to the environment and it is imperative to note that if current institutional controls fail or if the present contaminant source controls can no longer be maintained, the public would be at risk of environmental contamination.

Site Description

The DOE Oak Ridge Reservation (ORR), as shown in Figure 1, encompasses approximately 35,000 acres and three major operational DOE facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Y-12 Plant (Y-12), and the East Tennessee Technology Park (ETTP, formerly the K-25 Gaseous Diffusion Plant). The initial objectives of the ORR operations were the production of plutonium and the enrichment of uranium for nuclear weapons components. In the 60 + years since the ORR was established, a variety of production and research activities have generated numerous radioactive, hazardous, and mixed wastes. These wastes, along with wastes from other locations, were disposed of on the ORR. Early waste disposal methods on the ORR were rudimentary compared to today's standards.

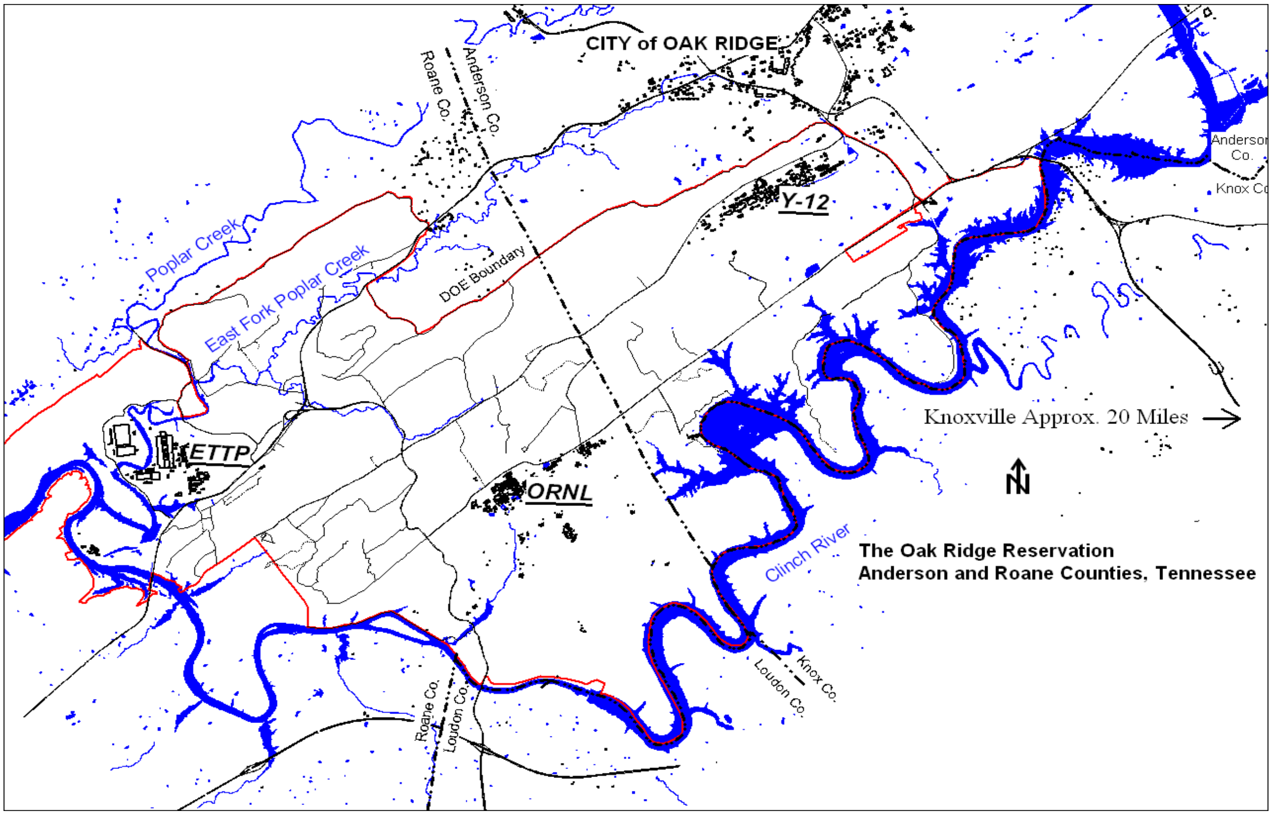


Figure 1: The Oak Ridge Reservation

The ORR is located within the corporate boundaries of the city of Oak Ridge, Tennessee, in the counties of Anderson and Roane. The Reservation is bounded on the north and east by residential areas of the city of Oak Ridge and on the south and west by the Clinch River. Counties adjacent to the Reservation include Knox, Loudon, and Morgan. Meigs and Rhea counties are immediately downstream on the Tennessee River from the ORR. The nearest cities are Oak Ridge, Oliver Springs, Kingston, Lenoir City, Harriman, Farragut, and Clinton. The nearest metropolitan area, Knoxville, lies approximately 20 miles to the east. Figure 2 depicts the general location of the Oak Ridge Reservation and nearby cities.

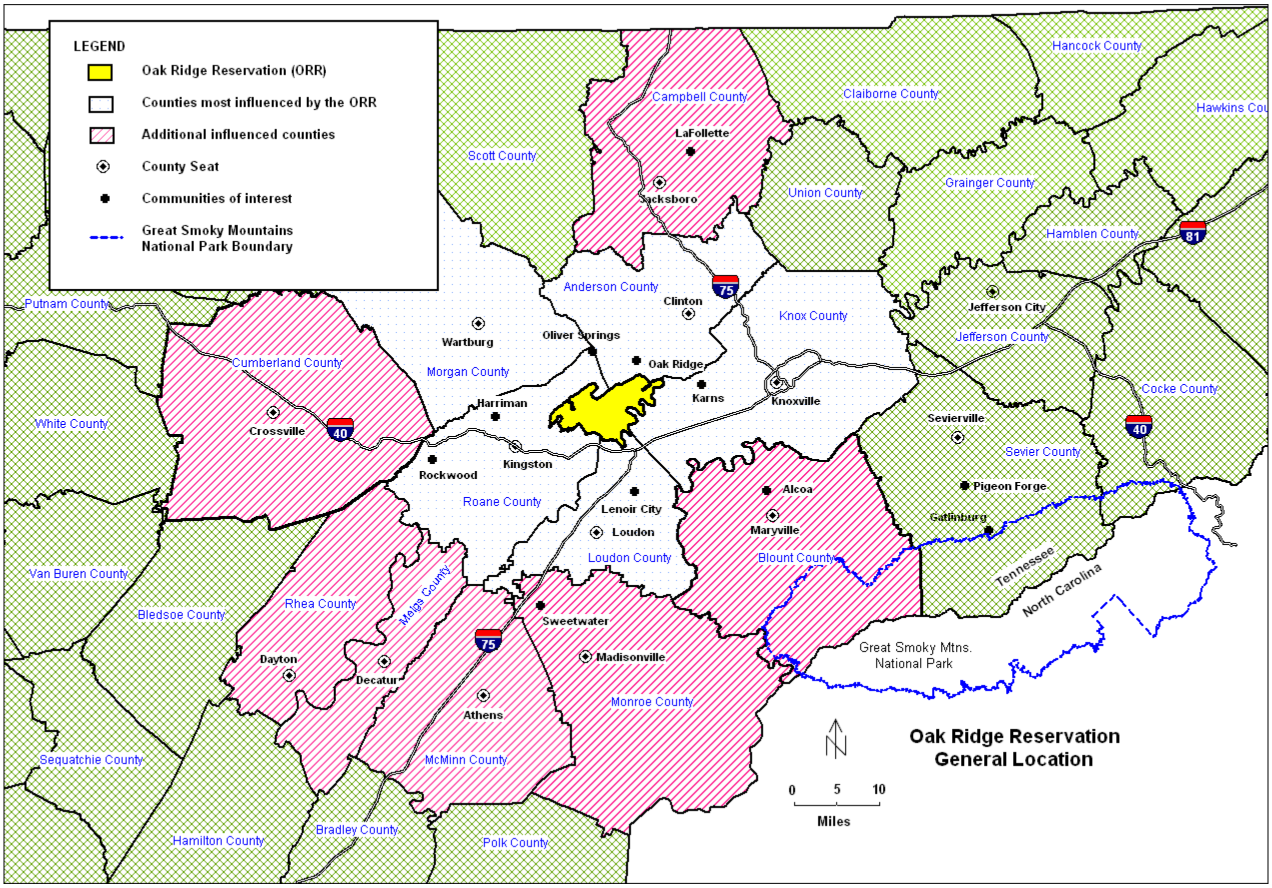


Figure 2: Location of the Oak Ridge Reservation

The ORR lies in the Valley and Ridge Physiographic Province of East Tennessee. The Valley and Ridge Province is a zone of complex geologic structures dominated by a series of thrust faults and characterized by a succession of elongated southwest-northeast trending valleys and ridges. In general, sandstones, limestones, and/or dolomites underlie the ridges that are relatively resistant to erosion. Weaker shales and more soluble carbonate rock units underlie the valleys.

The hydrogeology of the ORR is very complex with a number of variables influencing the direction, quantity, and velocity of groundwater flow that may or may not be evident from surface topography. In many areas of the ORR, groundwater appears to travel primarily along short flow paths in the storm flow zone to nearby streams. In other areas, evidence indicates substantial groundwater flow paths and, thereby, contaminant transport may occur preferentially in fractures and solution cavities in the bedrock for relatively long distances.

As seen in Figure 3, streams on the ORR drain to the Clinch River. Melton Hill Dam impounded the Clinch River in 1963. Contaminants released on the Oak Ridge Reservation enter area streams (e.g., White Oak Creek, Bear Creek, East Fork Poplar Creek, and Poplar Creek) and are transported into the Clinch River and Watts Bar Reservoir on the Tennessee River.

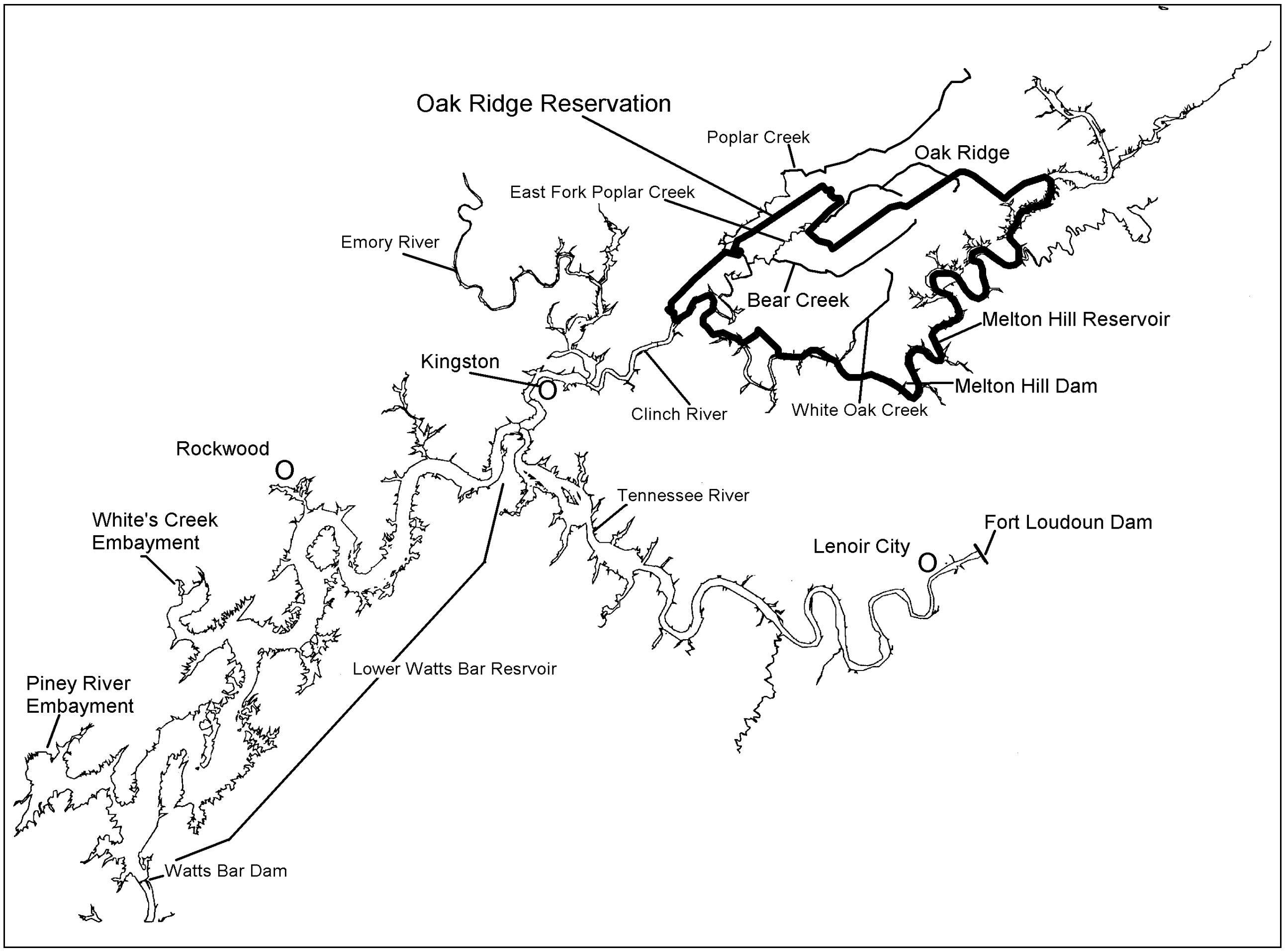


Figure 3: Watts Bar Reservoir

The climate of the region is moderately humid and the annual average precipitation is around 55 inches. Winds on the reservation are controlled, in large part, by the valley and ridge topography with prevailing winds moving up the valleys (northeasterly) during the daytime and down the valleys (southwesterly) at night.

Chapter 1 AIR QUALITY MONITORING

Hazardous Air Pollutants Metals Monitoring on East Tennessee Technology Park

Principal Author: Sid Jones

Abstract

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division's (DOE-O) Hazardous Air Pollutant (HAPs) Monitoring Program was developed to provide continued independent monitoring at the East Tennessee Technology Park (ETTP) and to verify the Department of Energy's (DOE) reported monitoring results. Monitoring was conducted for arsenic, beryllium, cadmium, total chromium, lead, nickel, and uranium as a metal.

The results of the 2005 monitoring conducted by TDEC at the ETTP sites indicate no apparent elevated levels of for hazardous air pollutants (HAPs) metals of concern. Analytical results for all metals of concern were below regulatory standards and risk specific doses listed in 40 CFR 266 Appendix V. Concentrations of lead in ambient air were comparable to those found in previous years, and were less than 1 percent of the national quarterly ambient air quality standard of 1.5 $\mu g/m^3$. The atmospheric lead concentrations were also consistent with those reported by DOE for past years.

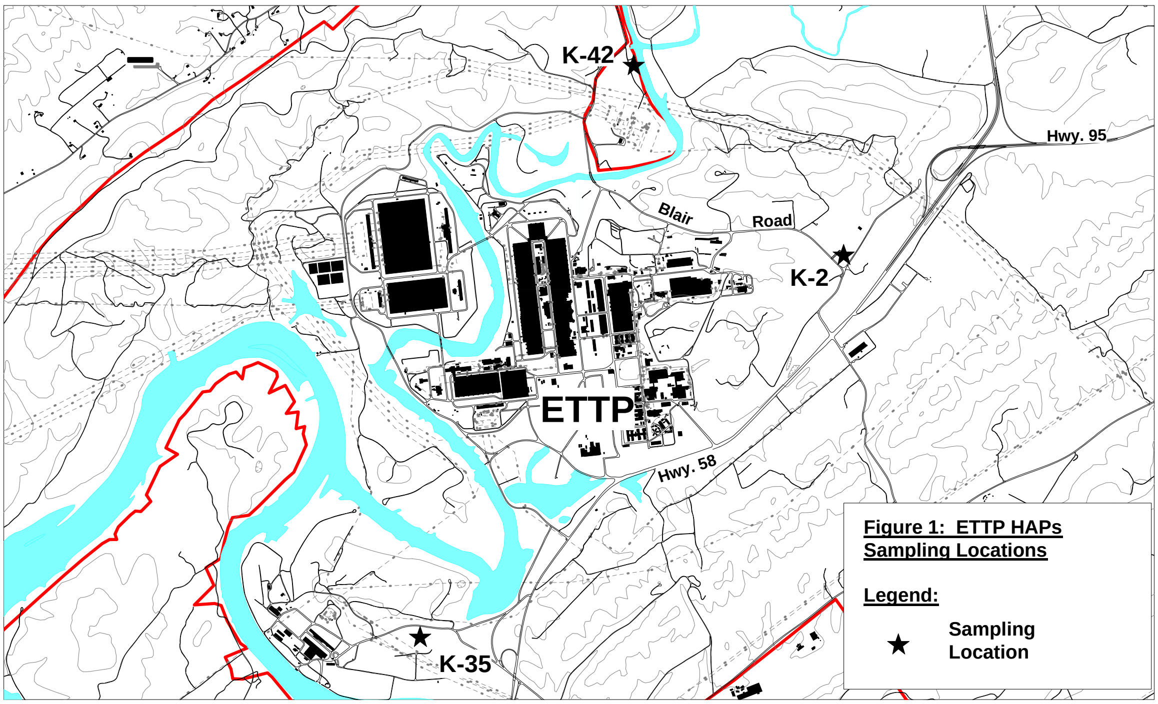
This project will continue to monitor for potential effects on the ORR at ETTP in order to provide independent monitoring to assure protection of human health and the environment. In the future, analytical methods and monitoring techniques will be altered to further facilitate comparison with DOE's air monitoring data.

Introduction

This independent monitoring project is conducted under authority of the Tennessee Oversight Agreement. It is a continuation of the ambient air-monitoring project initiated in 1997 in response to the heightened level of public concern regarding potential impacts to public health from the TSCA Incinerator emissions. Additionally, with the continuation of D&D activities as at the site, further analyses of the potential impacts, if any, of these projects on the ambient air on and around the ETTP site is warranted.

Title III of the Clean Air Act Amendments (CAAAs) has identified 189 toxic chemicals. These chemicals, called hazardous air pollutants, or HAPs, are known or suspected carcinogens, and have high usage and emissions in a wide variety of industries. Major stationary sources of HAPs are subject to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) found in Title III of the CAAAs of 1990. Rather than NESHAPs for each pollutant, the 1990 CAAAs direct EPA to set technology-based standards using maximum achievable control technologies (MACT) for 175 source categories which will require sharp reductions of routine emissions of toxic air pollutants.

In 1997, concerns were raised by members of the public regarding potential health effects due to possible concentrations of HAPs in the ambient air on and around ORR. In response to these concerns, TDEC/DOE-O's, Waste Management (WM) program developed an ambient air monitoring program for the ORR in order to determine what effects, if any, DOE operations were having on the ambient air on and around the reservation with regard to HAPs. This program was designed to provide an independent verification of monitoring results as reported by the DOE. Background data was collected at a site located near Norris Lake. This data was used in a comparative manner as a baseline for the area surrounding the ORR. Nickel and Uranium as a metal were added in 1999 to the list of metals of concern. Future Decontamination and Decommissioning (D&D) activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by TDEC.



ETTP

Methods and Materials

The ambient air sampling for this project has historically been conducted at stations co-located with DOE monitors K-2 (Blair Rd opposite the TSCA Incinerator), Perimeter Air Monitor K-42 (next to Poplar Creek) and Perimeter Air Monitor K-35 (Gallaher Rd Bridge area). The locations of these monitoring stations are shown in Figure 1.

The monitoring sites selected were chosen based upon wind data that indicated the sites were in the prevailing wind flow patterns for the region surrounding the ORR. The windflow during the day is a southwest to northeast pattern while during the night; the flow pattern is reversed. Placement of TDEC monitors allowed for sampling that would be more or less representative of a 24-hour windflow pattern at the ORR. An additional factor in selecting these locations was an availability of power source.

The monitoring schedule was modified somewhat in 2004, based on past sampling results and data reported in the Oak Ridge Reservation Annual Site Environmental Report (ASER). These data indicate that both lead and uranium average values are typically highest at the K-2 site. Of the 46 weeks for which data was collected in 2004, the sampler was located at the K-2 site approximately half of the time. In 2005, the air monitor was located permanently at K2 to facilitate comparison with DOE air monitoring data. Typically, filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis.

Table 1
HAPs metals ambient air sampling schedule, 2005

Monitoring period[1]	Sampling Locations	Sampling period	Collection frequency	Analysis frequency
01/01/05-12/31/05	K-2	Continuous	Weekly	Weekly

[1]Sampler stationed at K-2 monitoring location only in 2005.

Results and Discussion

Quarterly results for lead were determined from analyses of continuous weekly samples stations. Lead analytical results are summarized in Table 2 and are compared with the Tennessee and national quarterly ambient air quality standard of 1.5 μg/m^3. The results obtained indicate that this value was less than 1% of the quarterly standard.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2005 was not available. However, analytical results from the HAPs monitoring program since 2000 were compared with results from the 2001 through 2004 data from previous ASERs. In general, levels of lead found by TDEC and DOE were comparable in the ambient air at ETTP over this period, although DOE data exhibit a decreasing trend not evident in TDEC results.

Table 2
Lead concentration in ambient air at the ETTP, 2005

Station	Quarterly averages of weekly samples (μg/m^3)				Max quarterly result (μg/m^3)	Max weekly result (μg/m^3)	Max percent of quarterly standard (μg/m^3)[a]
	1	2	3	4			
K-2	0.003	0.003	0.003	0.004	0.004	0.006	<1
Quarterly max	0.004	0.004	0.006	0.005			<1
Tennessee and national quarterly ambient air quality standard of 1.5 μg/m^3							
Annual average for all stations = 0.0030 μg/m^3							

[a] Tennessee and national air quality standard for lead is 1.5 μg/m^3 quarterly arithmetic average.
[b] This station was not monitored this quarter.

Analyses of hazardous air pollutant carcinogenic metals (arsenic, beryllium, cadmium, chromium, and nickel) were performed on all collected continuous weekly samples. These analytical results are summarized in Table 3. There were no detected concentrations of beryllium, cadmium, nickel or uranium. Arsenic was detected in twelve of forty-seven samples and chromium in four of forty-three samples. There are no Tennessee or national ambient air quality standards for these hazardous air pollutants. The annual average concentrations were compared to risk specific doses and reference air concentrations as listed in 40 CFR 266.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2005 was not available. However, analytical results generated by the HAPs monitoring program over the past four years were compared with the ASER results since 2000. The ASER data indicated sporadic detection of hazardous air pollutant carcinogenic metals, with no quarterly concentrations exceeding the risk-specific doses. TDEC data include some weekly concentrations that significantly exceed maximum quarterly averages reported by DOE for both arsenic and chromium, but these remain well below risk-specific dose levels. Laboratory analyses for the air data reported in the DOE ASER were done using inductively coupled plasma mass spectrometry (ICP-MS), perhaps yielding better detection limits. Nickel was not included as a monitoring parameter in the ASER.

Table 3
Hazardous air pollutant carcinogenic metals concentration in ambient air at the ETTP, 2005

HAPs	**Ambient air concentration (μg/m³)**			**Annual concentration guideline (μg/m³)**	**Minimum detection limit (μg/m³)**
	Annual avg.	**Weekly max**	**Max location**		
Arsenic	<.0015	.002	NA	0.0023[a]	0.001
Beryllium	U	U	NA	0.004[a]	0.001
Cadmium	U	U	NA	0.0056[a]	0.001
Chromium	<.0006	.0006	NA	0.00083[a] Cr-VI 1000.0[a] Cr-III	.0005
Nickel	U	U	NA	0.042[a]	0.001
Uranium	U	U	NA	0.15[b]	0.01

U – Analyte not detected in laboratory analysis

[a] Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266, Appendix V.

[b] DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/m^3, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m^3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% ^{235}U.

Conclusion

The results of the 2005 monitoring conducted by TDEC at the ETTP sites indicate no apparent elevated levels of for hazardous air pollutants (HAPs) metals of concern. Analyses for all metals of concern were below regulatory standards or guidelines. This project has been re-authorized to continue into 2006. In 2006, the K-2 site will be monitored continuously and monitoring at the other sites will be dropped. Quarterly composite samples will be analyzed using an inductively coupled plasma – mass spectrometer method to facilitate comparison with DOE air monitoring data.

References

Boiler and Industrial Furnace Regulations - 40 CFR Part 266 Appendix V.

Draft New York State Air Guide-1, Guidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, 1994 Edition.

Operations Manual for GMW Model2000H Total Suspended Particulate Sampling System, 1998 Graseby GMW Variable Resistance Calibration Kit # G2835.

TDEC/DOE-O Procedure number: SOP-ES&H-004 Air Monitoring/Air Sampling

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee*. Oak Ridge, Tennessee.

Thomasson, D.A. 2005 *Health, Safety and Security Plan*, Tennessee Department of Environment and Conservation Department of Energy Oversight Division, Oak Ridge, Tennessee.

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Chapter 1 AIR QUALITY MONITORING

Hazardous Air Pollutants Metals Monitoring on Y-12 and ORNL (X-10)

Principal Author: Sid Jones

Abstract

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division's (the division) Hazardous Air Pollutant (HAPs) Monitoring Program was developed to provide continued independent monitoring of hazardous metals in ambient air at the Oak Ridge National Lab (ORNL or X-10) and Y-12 National Security Complex (Y-12). Monitoring with high volume air samplers was conducted for arsenic, beryllium, cadmium, total chromium, lead, nickel, and uranium as a metal.

Although a number of sources that have the potential to emit hazardous metals are located on and around the Oak Ridge Reservation (ORR), the results of the 2005 monitoring conducted by TDEC at the Y-12 and ORNL sites indicate no locally elevated levels of hazardous air pollutants (HAPs) metals of concern. Analyses for all metals of concern were below regulatory reference values. Lead concentrations remain at less than one percent of the air quality standard. Beryllium, cadmium, and uranium as a metal were not detected at either site. Total chromium was detected in 5 of 36 samples at Y-12 and in 4 of 42 samples at X-10. Nickel was detected only once at X-10 and was undetected at Y-12. Arsenic was detected in 15 of 46 samples at X-10 and in 18 of 41 samples at Y-12.

This project will continue to monitor for hazardous metals in ambient air on the ORR at Y-12 and ORNL. The goal is to provide independent air monitoring to assure protection of human health and the environment. Historical data generated by this office and by DOE will be reviewed to refine or change sampling techniques, analytical methods, or location of samplers.

Introduction

Title III of the Clean Air Act Amendments (CAAAs) identified 189 toxic chemicals. These chemicals, called hazardous air pollutants or HAPs, are known or suspected carcinogens, and have high usage and emissions in a wide variety of industries. Major stationary sources of HAPs are subject to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) found in Title III of the CAAAs of 1990. Rather than establishing NESHAPs for each pollutant, the 1990 CAAAs directed EPA to set technology-based standards using maximum achievable control technologies (MACT) for 175 source categories which will require sharp reductions of routine emissions of toxic air pollutants.

In 1997, concerns were raised by members of the public regarding potential health effects due to possible concentrations of HAPs in the ambient air on and around ORR. In response to these concerns, the division's Waste Management (WM) program developed an ambient air monitoring program for the ORR in order to determine what effects, if any, DOE operations were having on the ambient air on and around the reservation with regard to HAPs. This program was designed to provide an independent verification of monitoring results as reported by the DOE. Background data was collected at a site located near Norris Lake. This data was used to establish a baseline for the area surrounding the ORR. Nickel and Uranium as a metal were added in 1999 to the list of metals of concern.

ORNL

Monitoring at ORNL was conducted at stations located at both the east and west ends of this facility. The western site is co-located at the Perimeter Air Monitor (PAM) 3 off Bethel Valley Road. The monitor at the east-end of ORNL is co-located with Meteorological Tower 3. See Figure 1.

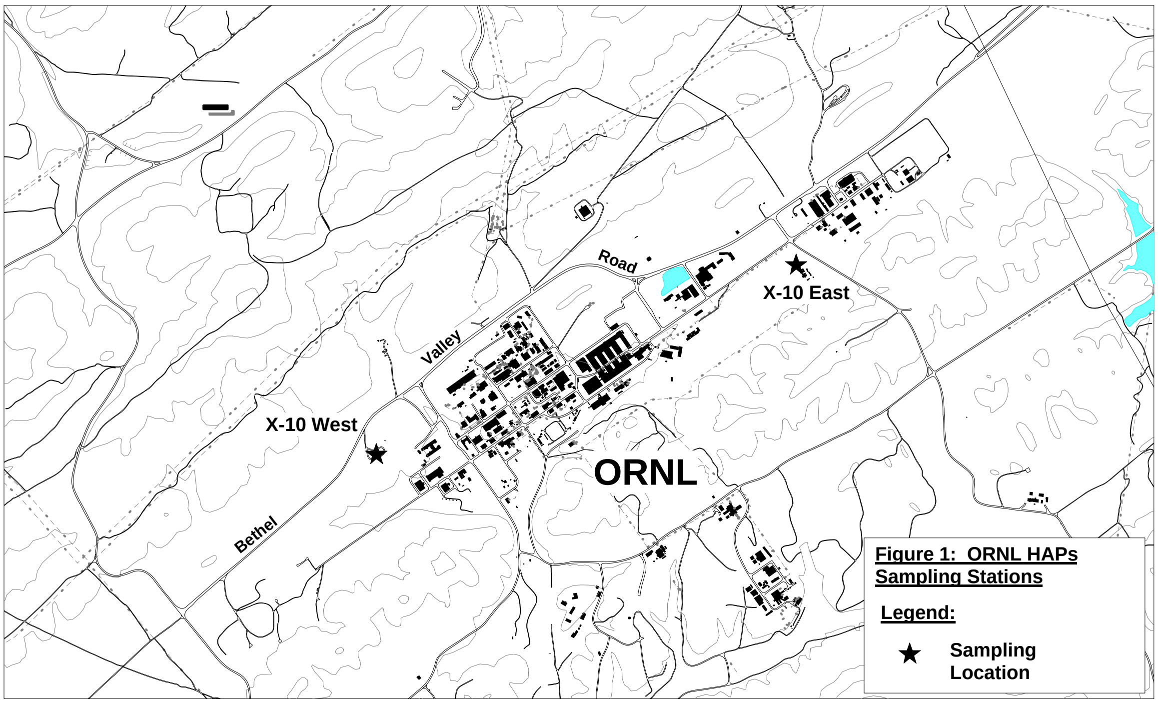

Figure 1: ORNL HAPs Sampling Stations

Y12

Monitoring at Y-12 was conducted at stations located at both the east and west ends of this facility. The site at the west-end of Y-12 is co-located with Meteorological Tower 6 on Bear Creek Valley Road. The monitoring site at the east-end of Y-12 is co-located with Meteorological Tower 5. See Figure 2.

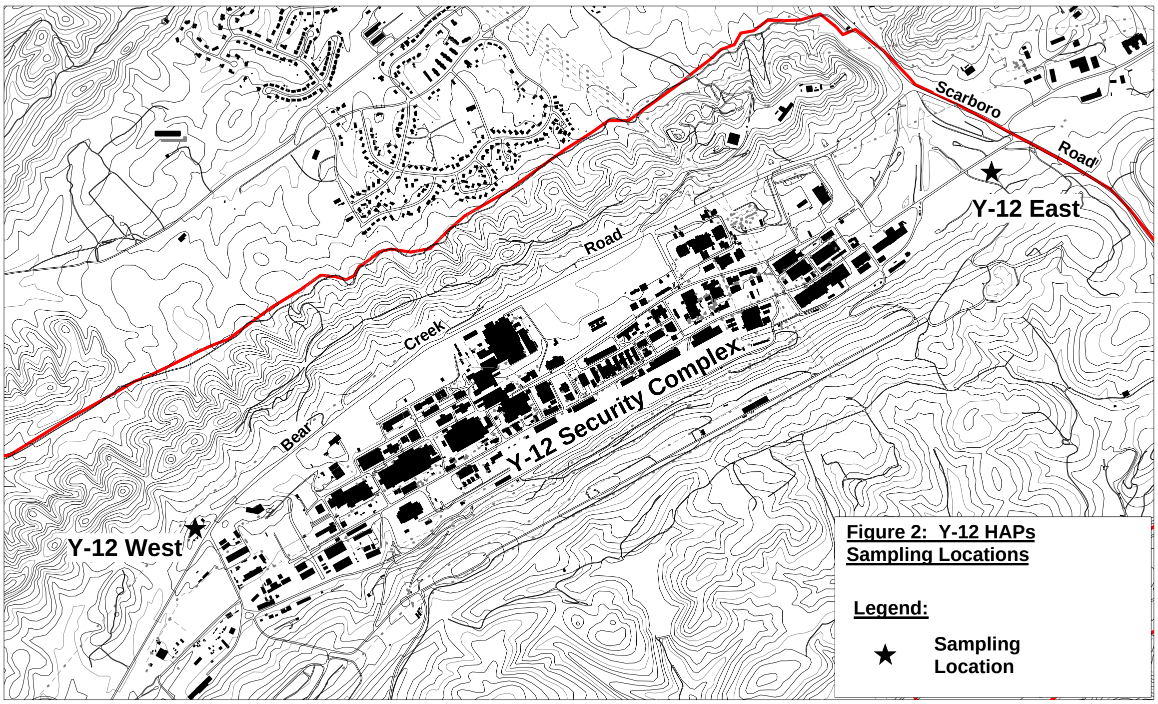

Figure 2: Y-12 HAPs Sampling Locations

Methods and Materials

The monitoring sites selected were chosen based upon wind rose data that indicated the sites were in the prevailing wind flow patterns for the region surrounding the ORR. The windflow during the day is a southwest to northeast pattern while during the night; the flow pattern is reversed. The placement of TDEC's monitors allow for sampling that would be representative of a 24-hour windflow pattern at the ORR. An additional factor in selecting these locations was the availability of a power source.

Filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis. The principal parameters monitored during 2005 were arsenic, beryllium, cadmium, total chromium, lead, nickel, and uranium. Uranium was analyzed as a metal (by inorganic method). The ambient air sampling schedules for ORNL and Y-12 are listed in Table 1 and Table 2 respectively.

Results and Discussion

Table 1
HAPs metals ambient air sampling schedule, 2005 at ORNL

Monitoring period[1]	Sampling Locations	Sampling period	Collection frequency	Analysis frequency
01/01/05-03/11/05	X-10 W	Continuous	Weekly	Weekly
03/11/05-05/06/05	X-10 E	Continuous	Weekly	Weekly
05/06/05-07/22/05	X-10 W	Continuous	Weekly	Weekly
07/22/05-12/31/05	X-10 E	Continuous	Weekly	Weekly

[1]Sampler rotated between X-10 E and X-10 W monitoring locations.

Table 2
HAPs metals ambient air sampling schedule, 2005 at Y-12

Monitoring period[1]	Sampling Locations	Sampling period	Collection frequency	Analysis frequency
01/01/05-02/11/05	Y-12 W	Continuous	Weekly	Weekly
2/11/05-5/13/05	Y-12 E	Continuous	Weekly	Weekly
5/13/05-8/05/05	Y-12 W	Continuous	Weekly	Weekly
8/05/05-12/31/05	Y-12 E	Continuous	Weekly	Weekly

[1]Sampler rotated between Y-12 E and Y-12 W monitoring locations.

Quarterly lead results were determined from analyses of continuous weekly samples from stations X-10 E and X-10 W at ORNL and from stations Y-12 E and Y-12 W at the Y-12 site. Lead analytical results are summarized in Table 3 and Table 4 and are compared with the Tennessee and national quarterly ambient air quality standard of 1.5 $\mu g/m^3$. At both ORNL and Y-12 the results obtained indicate that this value was only <1% of the quarterly standard.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2005 was not available. Analytical results generated from the HAPs monitoring program over the past four years were compared with the ASER results since 2000, indicating comparable levels of lead in the ambient air in and around the ORR.

Table 3
Lead concentration in ambient air, 2005 at ORNL

Station	Quarterly averages of weekly samples (μg/m³) 1	2	3	4	Max quarterly average (μg/m³)	Max weekly result (μg/m³)	Max percent of quarterly standard (μg/m³)[a]
X-10 E	0.004	0.004	0.004	0.004	0.004	0.009	<1
X-10 W	0.003	0.004	0.003	b	0.004	0.008	<1
Weekly max	0.005	0.008	0.009	0.007			<1
Tennessee and national quarterly ambient air quality standard of 1.5 μg/m³							
Annual average for all stations = 0.004 μg/m³							

[a] Tennessee and national air quality standard for lead is 1.5 μg/m³ quarterly arithmetic average.

Table 4
Lead concentration in ambient air, 2005 at Y-12

Station	Quarterly averages of weekly samples (μg/m³) 1	2	3	4	Max quarterly average (μg/m³)	Max weekly result (μg/m³)	Max percent of quarterly standard (μg/m³)[a]
Y-12 E	0.003	0.004	b	0.004	0.004	0.006	<1
Y-12 W	0.003	0.004	0.003	b	0.004	0.004	<1
Weekly max	0.004	0.006	0.004	0.005			<1
Tennessee and national quarterly ambient air quality standard of 1.5 μg/m³							
Annual average for all stations = 0.003 μg/m³							

[a] Tennessee and national air quality standard for lead is 1.5 μg/m³ quarterly arithmetic average.
[b] This station was not monitored this quarter.

Analyses of hazardous air pollutant carcinogenic metals (arsenic, beryllium, cadmium, chromium, and nickel) were performed on all collected continuous weekly samples from stations X-10 E and X-10 W at ORNL and from stations Y-12 E and Y-12 W at the Y-12 site. These analytical results are summarized in Table 5 and Table 6. There isn't any Tennessee or national ambient air quality standards for these hazardous air pollutants. The average concentrations were compared to risk specific doses and reference air concentrations as listed in 40 CFR 266, Appendix V.

Beryllium, cadmium, and uranium as a metal were not detected at either site. Total chromium was detected in 5 of 36 samples at Y-12 and in 4 of 42 samples at X-10. Nickel was detected only once at X-10 and was undetected at Y-12. Arsenic was detected in 15 of 46 samples at X-10 and in 18 of 41 samples at Y-12. At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2005 was not available. However, analytical results from 2001 through 2004 generated from this monitoring program were compared with the ASER data since 2000. The ASER data indicated sporadic detection of hazardous air pollutant carcinogenic metals, with all quarterly average concentrations below the risk-specific doses. Nickel was not included as a monitoring parameter in the ASER. The maximum concentration of uranium was reported, by DOE in the 2002 ASER, as less than one per cent of Derived Concentration Guide of 0.15μg/m^3.

Table 5
Hazardous air pollutant carcinogenic metals concentration in ambient air, 2005 at ORNL

HAPs	Ambient air concentration (μg/m^3)			Annual concentration guideline (μg/m^3)	Percentage of standard (guideline)	Minimum Detection Limit (μg/m^3)
	Annual avg.	Weekly max	Max location			
Arsenic	< .0015	.002	X10E, X10W	0.0023[a]	<65	0.001
Beryllium	U	U		0.004[a]	U	0.001
Cadmium	U	U		0.0056[a]	U	0.001
Chromium	< .0006	.0007	X10E	0.00083[a] Cr-VI 1000.0[a] Cr-III	<72	0.0005
Nickel	U	U		0.042[a]	U	0.001
Uranium	U	U		0.15[b]	U	0.01

U – Analyte not detected in laboratory analysis

[a] Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266.

[b] DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/m^3, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m^3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% ^{235}U.

Table 6
Hazardous air pollutant carcinogenic metals concentration in ambient air, 2005 at Y-12

HAPs	Ambient air concentration (μg/m^3)			Annual concentration guideline (μg/m^3)	Percentage of standard (guideline)	Minimum Detection Limit (μg/m^3)
	Annual avg.	Weekly max	Max location			
Arsenic	<.0015	.002	Y12E, Y12W	0.0023[a]	<65	0.001
Beryllium	U	U		0.004[a]	U	0.001
Cadmium	U	U		0.0056[a]	U	0.001
Chromium	<.0006	.0007	Y12E	0.00083[a] Cr-VI 1000.0[a] Cr-III	<72	0.0005
Nickel	U	U		0.042[a]	U	0.001
Uranium	U	U		0.15[b]	U	0.01

U – Analyte not detected in laboratory analysis

[a] Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266.

[b] DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/m^3, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m^3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% ^{235}U.

Conclusion

The results of the 2005 monitoring conducted by TDEC at ORNL and Y-12 sites indicate no apparent elevated levels of for hazardous air pollutants (HAPs) metals of concern. Analyses for all metals of concern were below guidelines. This project has been re-authorized to continue into 2006. The monitors will be stationary at the east sampling sites for the year 2006 unless changes in DOE operations dictate a change in monitoring locations.

References

Boiler and Industrial Furnace Regulations - 40 CFR Part 266 Appendix V.

Draft New York State Air Guide-1, Guidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, 1994 Edition.

Operations Manual for GMW Model2000H Total Suspended Particulate Sampling System, 1998 Graseby GMW Variable Resistance Calibration Kit # G2835.

TDEC/DOE-O Procedure number: SOP-ES&H-004 Air Monitoring/Air Sampling.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee*. Oak Ridge, Tennessee.

Thomasson, D.A. 2005 *Health, Safety and Security Plan*, Tennessee Department of Environment and Conservation Department of Energy Oversight Division, Oak Ridge, Tennessee.

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Chapter 1 AIR QUALITY MONITORING

Oak Ridge Reservation Perimeter Ambient Air Monitoring Program (RMO)

Principal Authors: Howard Crabtree, Natalie Pheasant

Abstract

The Tennessee Department of Environment and Conservation's Perimeter Air Monitoring Program performs radiochemical analysis on samples collected from twelve low volume air samplers stationed at exit pathways from the Oak Ridge Reservation. This program, in conjunction with associated air monitoring programs, provides information used to assess the impact of Department of Energy activities on the local environment and public health. In the program, samples are collected biweekly from twelve air monitors stationed near the boundaries of the reservation and at a background location. Each sample is analyzed for gross alpha and gross beta radiation at the state radiochemistry laboratory. A composite sample from each location is analyzed annually for gamma emitters. Results are compared to the background measurements and environmental standards provided in the Clean Air Act. The data for 2005 did not indicate a significant impact on local air quality from activities on the reservation.

Introduction

The Tennessee Department of Environment and Conservation (TDEC), Department of DOE Oversight Division provides radiochemical analysis of air samples taken from twelve low volume air monitors located on and in the vicinity of the Oak Ridge Reservation (ORR). The monitors used to collect the samples are owned by DOE and maintained by DOE contractors. Data derived from this program, along with information generated by the other air monitoring programs on the reservation, are used to:

- Assess the impact of DOE activities on the public health and environment,
- Identify and characterize unplanned releases,
- Establish trends in air quality, and
- Verify data generated by DOE and its contractors

Methods and Materials

The twelve low-volume air samplers used in the program are owned by DOE and DOE contractors are responsible for their maintenance and calibration. Nine of these samplers are also used by DOE contractors to collect tritium samples. The division's samples are collected on filters in the units that are removed by DOE contractors when the tritium samples are collected. The remaining three samples are collected by staff from monitors previously used by the Y-12 complex in their perimeter air monitoring program.

Each of the samplers in the program uses forty-seven millimeter borosilicate glass fiber filters to collect particulates as air is pulled through the units. The ORR perimeter monitors employ a pump and flow controller to maintain airflow through the filters at approximately two standard cubic feet per minute. The Y-12 monitors use a pump and rotometer, which are set to average approximately two standard cubic feet per minute.

The filters from each monitor are collected biweekly and shipped to the state's radiochemical laboratory in Nashville, Tennessee, for analysis. Analysis includes gross alpha and gross beta on the biweekly samples. Gamma spectrometry is performed on samples that exhibit elevated gross alpha or beta results and annually on composite samples.

The twelve air monitoring stations used in the program are listed in Table 1. Eleven of these stations are located around the perimeter of the ORR and Y-12 facility (Figure 1). The twelfth site is a background station located near Fort Loudoun Dam in Loudon County.

Table 1: Perimeter Air Monitoring Stations

Station	Location	County
4	Y-12 Perimeter near portal 2	Anderson
5	Y-12 Perimeter near Building 9212	Anderson
8	Y-12 Perimeter west end near portal 17	Anderson
35	East Tennessee Technology Park	Roane
37	Bear Creek at Y-12 / Pine Ridge	Roane
38	Westwood Community	Roane
39	Cesium Fields at Oak Ridge National Laboratory	Roane
40	Y-12 East	Anderson
42	East Tennessee Technology Park off Blair Road	Roane
46	Scarboro Community	Anderson
48	Deer Check Station on Bethel Valley Road	Anderson
52	Fort Loudoun Dam (Background Station)	Loudon

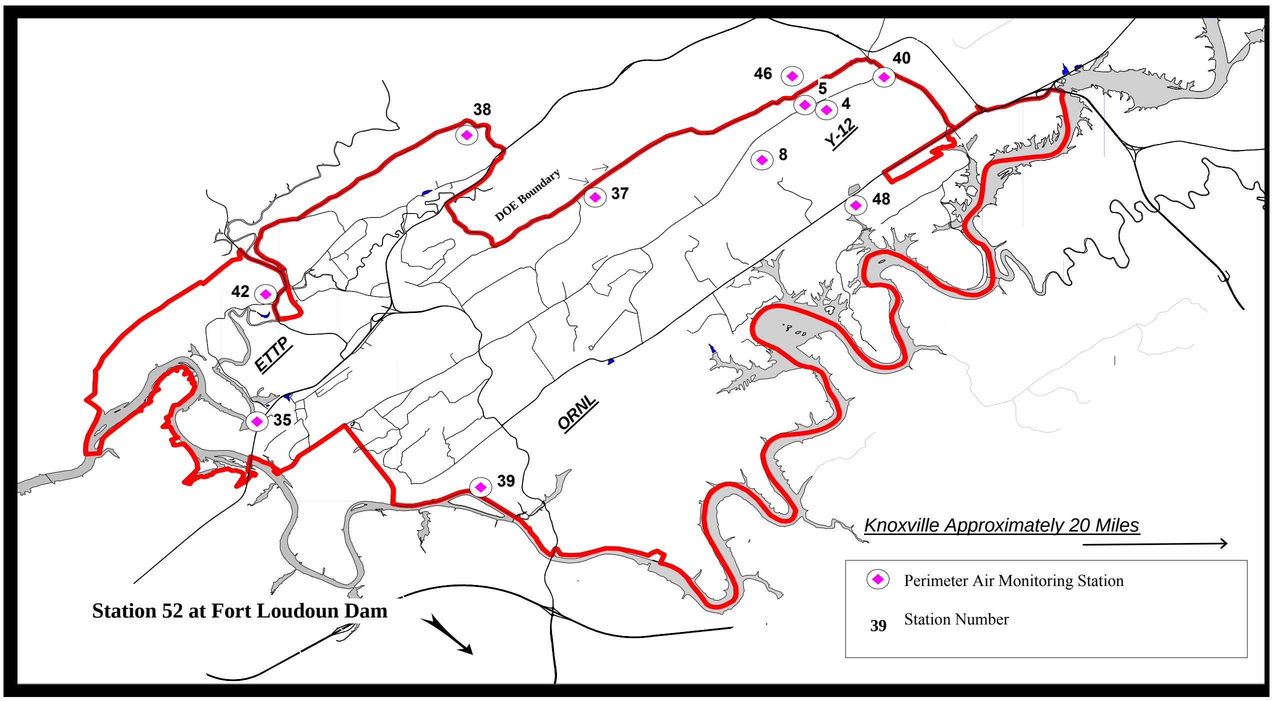

Figure 1: Approximate Location of Perimeter Air Monitoring Stations

Results and Discussion

Figures 2 and 3 illustrate the correlation between fluctuations in the gross alpha and beta results at the perimeter stations and the background location. These fluctuations, to a large degree, can be attributed to natural phenomena or changing environmental conditions, which increase or decrease the amount of particulate deposited on the sampling filters. For example, concentrations of potassium-40 and radionuclides in the uranium and thorium decay series may increase, because soils in which they naturally occur have been dispersed in the air as a consequence of dry conditions, heavy winds, and/or local activities (e.g., construction). Conversely, rain and snow can remove materials suspended in the air reducing the concentration of contaminants deposited on the air filters.

In general, results reported in 2005 for the perimeter air monitoring stations were near those reported for the background station. Similar trends in the activities for gross alpha and beta were observed for each monitoring station, with one exception. The results for samples collected in August from station 38 (located in the Woodbury Community) were considerably lower than the other results reported for the month. In September, the results for station 38 rose to levels above the other the sampling stations. This pattern (very low to high results) suggests the anomalous data was due to an equipment malfunction or sampling error, but the exact cause is unknown.

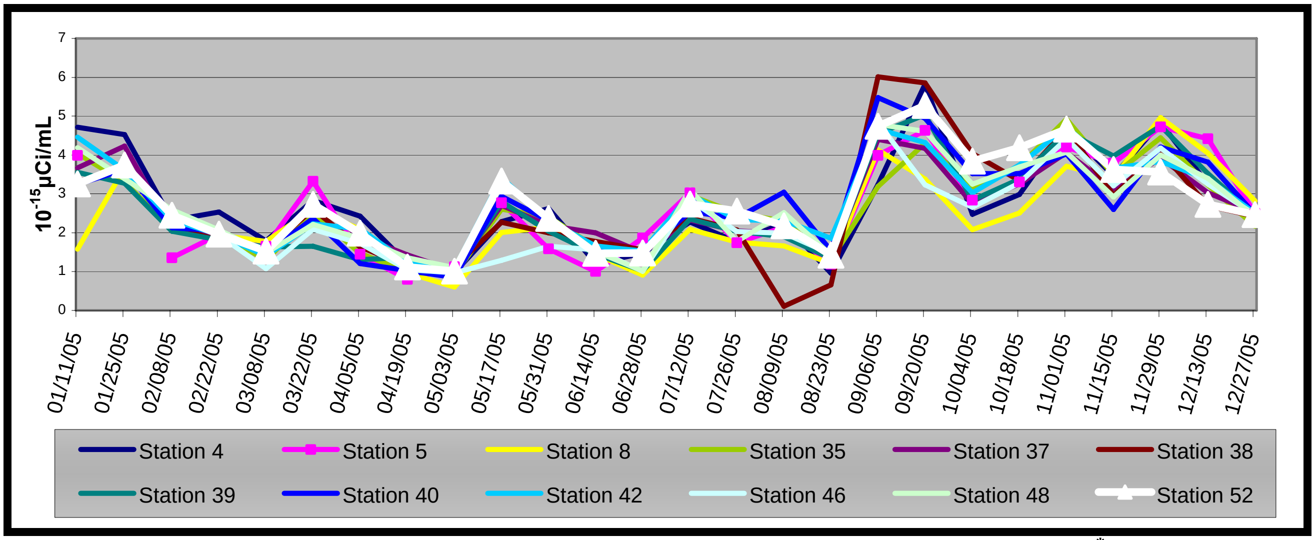

Figure 2: 2005 Gross Alpha Results for TDEC ORR Perimeter Air Monitoring Stations*

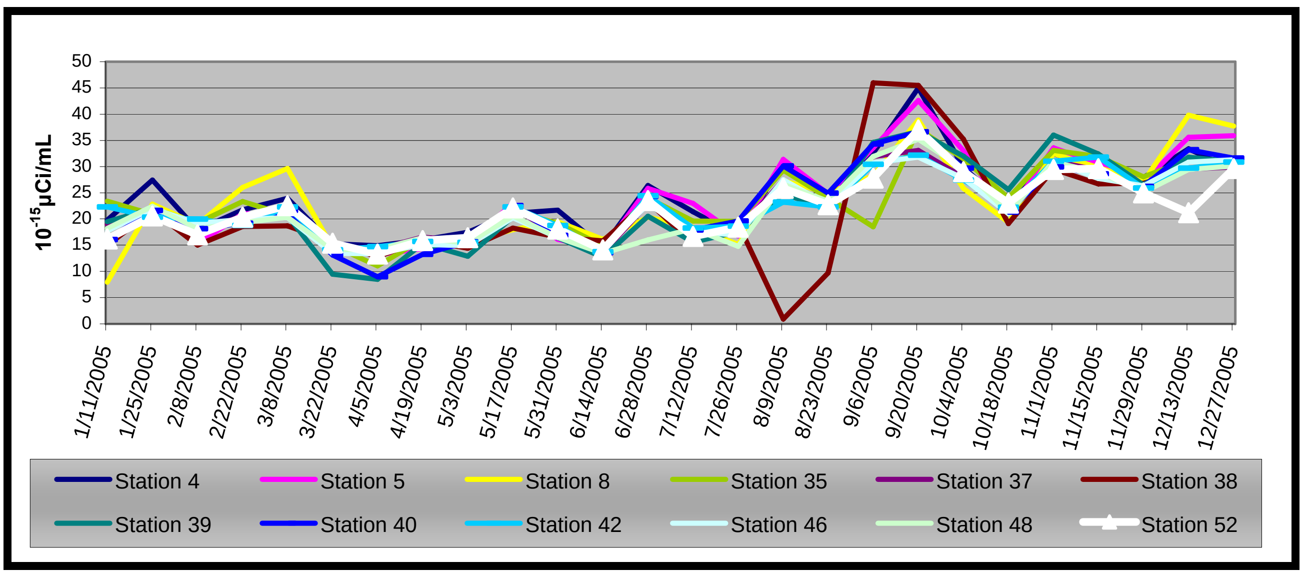

Figure 3: 2005 Gross Beta Results for TDEC ORR Perimeter Air Monitoring Stations*

The simplest method of assessing the impact of ORR air emissions on the local environment is to compare results from the perimeter monitoring stations to those of the background station located at Fort Loudoun Dam (Station 52). As can be seen in Figures 2 through 5, the activities reported

*Figures 2 and 3 are intended to convey the correlation of the results for the various monitoring stations: not depict individual results. Individual measurements are available at the division's offices, for the perimeter air monitoring stations for gross alpha and gross beta were relatively consistent with the background values, with the exception previously noted.

The Clean Air Act (CAA) specifies that exposures to the public from radioactive materials released to the atmosphere from DOE facilities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem above background measurements. Data from TDEC's air monitoring is compared to ambient air concentrations provided in the CAA for demonstrating compliance with the 10 mrem/year limit. While the CAA environmental standards do not include limits for gross alpha and beta, these measurements provide an effective tool to assess if further analysis is merited.

Figures 4 and 5 show the average activity for gross alpha and beta measured during the year 2005 at the perimeter air stations. The CAA environmental standards (adjusted to include background radiation) for uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter) are provided for comparison. These isotopes have some of the more restrictive standards prescribed by the CAA. It should be understood that it is very unlikely that these isotopes would be responsible for a major proportion of the gross activity reported for the samples.

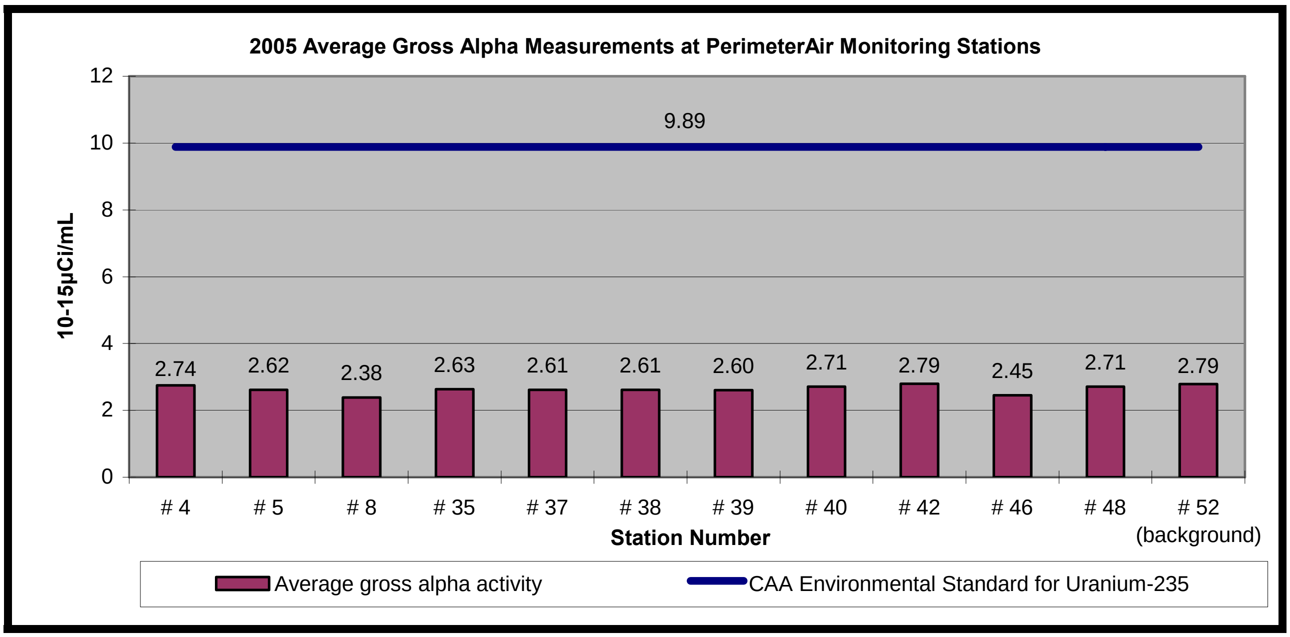

Figure 4: 2005 Average Gross Alpha Results for TDEC Perimeter Air Monitoring Stations on the ORR
*The standards provided by the Clean Air Act apply to the dose above background: therefore, the standard provided for reference in the figure has been adjusted to include the background measurements.
**The CAA's Environmental limit for uranium-235 is provided for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

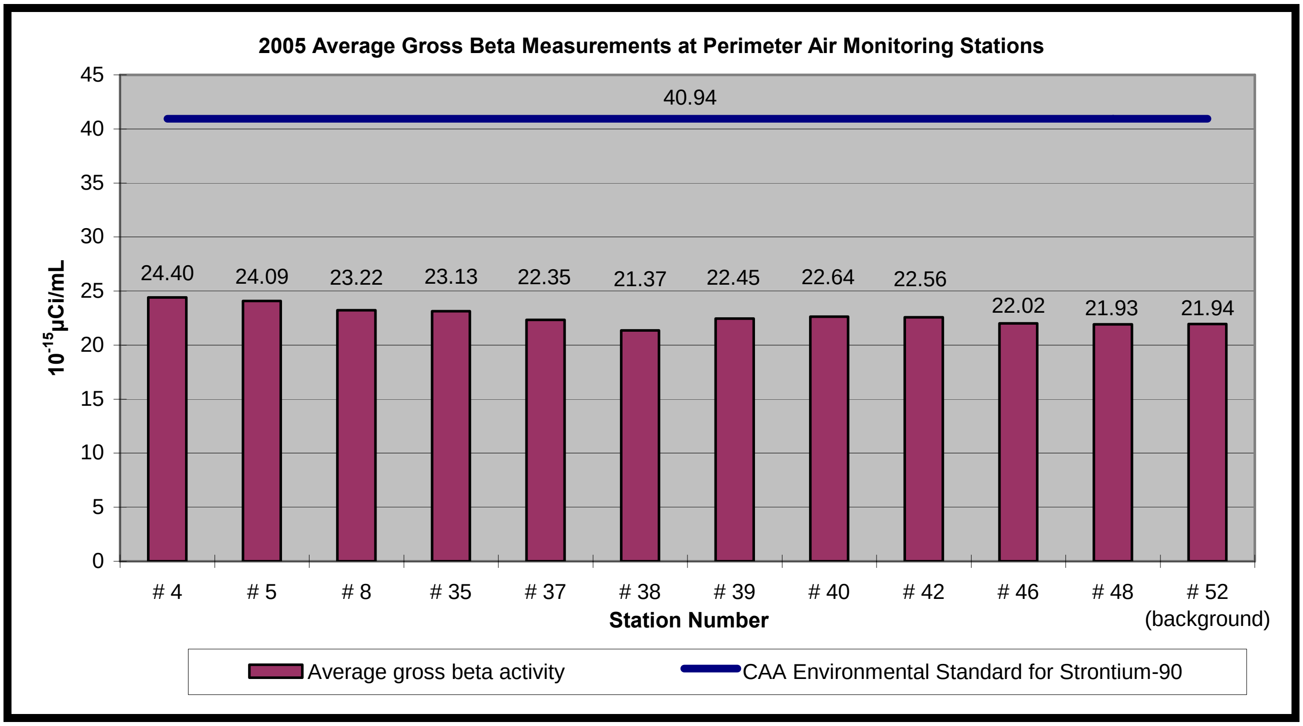

Figure 5: 2005 Average Gross Beta Results for TDEC Perimeter Air Monitoring Stations on the ORR

*****The standards provided by the Clean Air Act apply to the dose above background: therefore, the standard provided for reference in the figure has been adjusted to include the background measurement.

**The CAA's Environmental Limit for strontium-90 is provided for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

The annual gamma analysis performed on composite samples from each station has not been completed; consequently, these results were not available for this report. In the past, the gamma results have been considered consistent with background measurements.

Conclusion

Environmental concentrations of radionuclides in the atmosphere tend to vary from location to location and seasonally in response to natural and anthropogenic influences. In this regard, results of radiochemical analysis of samples taken at ORR perimeter air monitoring stations in 2005 follow similar trends to those from the background station located near Fort Loudoun Dam. In general the concentrations of these materials were also consistent with data reported for the background station, although anomalous results were reported for station 38 in the Woodbury Community. These data are believed to be due to an equipment malfunction or sampling error. All the results in 2005 were within CAA standards.

References

Environmental Protection Agency (EPA) 1994. *Clean Air Act.* 40 CFR Part 61, Subpart H. National Emissions Standards for Hazardous Air Pollutants (NESHAPS).

National Council on Radiation Protection and Measurements (NCRP), 1985. *Environmental Radiation Measurements.* NCRP report No. 50. August 1, 1985.

Oak Ridge Institute for Science and Education (ORISE), 1993. *Environmental Air Sampling.* Handout from Applied Health Physics Course (PWF:jb). June 8, 1993.

Tennessee Department of Environment and Conservation, 2004. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Environmental Monitoring Plan January through December 2005*. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the Department of Energy and the State of Tennessee*. Oak Ridge, Tennessee.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

CHAPTER 1 AIR QUALITY MONITORING

Fugitive Radiological Air Emissions Monitoring (RMO)

Principal Authors: Natalie Pheasant, Howard Crabtree

Abstract
The Tennessee Department of Environment and Conservation uses mobile, high-volume air samplers to monitor radioactive air emissions released from non-point sources on the Oak Ridge Reservation. Monitoring performed in the program focuses on fugitive/diffuse emissions that may be released during remedial and waste management activities. In 2005, the division deployed four air monitors in the program. One of the samplers was stationed in Loudon County to collect background data. Another sampler was positioned to monitor waste disposal activities at the Environmental Management Waste Management Facility in Bear Creek Valley. The two remaining samplers were placed at the East Tennessee Technology Park to monitor the decontamination and demolition of contaminated facilities at the site. The results for 2005 for monitoring stations on the reservation were similar to the background values and all results where lower than screening values used to assess compliance with Clean Air Act standards.

Introduction
The Tennessee Department of Environment and Conservation's DOE Oversight Division conducts routine monitoring of fugitive air emissions on the Oak Ridge Reservation (ORR). Sampling in the program focuses on locations where there is a potential for the release of radioactive emissions from non-point sources due to remedial or waste management activities. Four high-volume air samplers are used in the program. One sampler has been permanently stationed at Fort Loudoun Dam in Loudon County to collect background data. The remaining samplers have been mounted on trailers, allowing them to be moved to different locations as remedial activities progress. To evaluate the results, data from the mobile samplers are compared to the background data and dose limits specified in the Clean Air Act (CAA).

In December 2004, one of the mobile samplers was placed in the southeast corner of the Environmental Management Waste Management Facility (EMWMF). Located in Bear Creek Valley, this facility was opened in 2002 to dispose of wastes generated by CERCLA activities on the ORR. During disposal and prior to capping, waste disposed in the facility is subject to dispersion by winds that blow up (northeast) and down (southwest) through the valley.

The two remaining samplers were placed at the East Tennessee Technology Park (ETTP) to monitor decontamination, decommissioning, and demolition of contaminated facilities at the site. Many of these facilities were constructed in the World War II era to produce or support the production of enriched of uranium for nuclear weapons. As a consequence of operational practices and accidental releases, many of the approximately 500 facilities scheduled for demolition at ETTP are contaminated to some degree. Uranium isotopes are the primary contaminants, but transuranic radionuclides (e.g., neptunium-237, plutonium-239) and technetium-99 from the processing of recycled reactor fuel are also known to be present.

One of the ETTP samplers was placed to the northeast of the K-25 Process Building in December 2004. Currently undergoing demolition, the building housed the first production facility built to produce highly enriched uranium by gaseous diffusion. The largest building in the nation when it began operations in 1945, K-25 stands four stories high and covers approximately 40 acres. Both the building and equipment were extensively contaminated during operations.

The second sampler at ETTP was positioned next to the K-1420 Decontamination and Uranium Recovery Facility in October 2005. The K-1420 facility was constructed in 1954 for decontamination and uranium recovery operations, including the disassembly and chemical decontamination of gaseous diffusion equipment. Known to contain significant contamination, radiation dose measurements taken in the division's Environmental Dosimetry Program from an outside wall of the building have consistently been reported at relatively high levels (716 mrem for 2005). In 1999, DOE's Reindustrialization Program contracted with a private firm to decontaminate the facility, in exchange for the use of space in the building after the project was completed. The effort was abandoned following a contract dispute and the facility was subsequently scheduled for demolition, which is currently underway.

Methods and Materials

The project's four high-volume samplers use 8x10 inch, glass-fiber filters to collect particulates as air is drawn through the units at a rate of approximately 35 cubic feet per minute. Airflow is calibrated quarterly, using a Graseby General Metal Works Variable Resistance Calibration Kit (#G2835). The filters are collected weekly from each of the samplers and shipped to the state's radiochemical laboratory in Nashville, Tennessee, for analysis.

Analysis includes gross alpha, gross beta, and gamma spectrometry on each of the weekly samples, with additional analysis performed if merited. Results from the ORR samplers are compared to background data to determine if releases appear to be occurring. The data are then compared to environmental standards provided in the CAA (Appendix E Table 2 of 40 CFR 61) to assess if any releases are likely to have exceeded the Clean Air Act dose limit for members of the public (10 mrem/year) and if more invetsigation/analyis is warranted.

Results and Discussion

2005 Results vs. Background Data

Figures 1 and 2 illustrate the correlation between the gross alpha and beta results at the three ORR monitoring stations and the background location. To a large degree, the fluctuations that can be observed in the figures are attributable to regional weather conditions (e.g., wind and rain) that increase or decrease the amount of particulates in the air and, thereby, the amount deposited on the sampling filters. If there have been no releases, the data from the background and ORR samplers should be relatively similar, given allowances for localized conditions and analytical uncertainties. Results that significantly exceed the measurements at the background station are considered indicative of a release.

As can be noted in figures 1 and 2, the data for the ORR monitoring stations were relatively consistent with the background data in 2005, with two exceptions. In both of these cases, the result was for gross alpha in a sample colleted in November at the K-1420 Decontamination and Uranium Recovery Facility. These results are represented by the two lone peaks in Figure 1, during the November time frame. While it seems probable the results are due to activities at the K-1420 facility, the measurements are within the range of background concentrations and do not represent substantial concentrations when compared to the CAA standards.

It should be noted that the gaps in the line representing the results for the EMWMF monitor in Figures 1 and 2 reflect time periods when data was not collected, due problems encountered with the power source for the sampler.

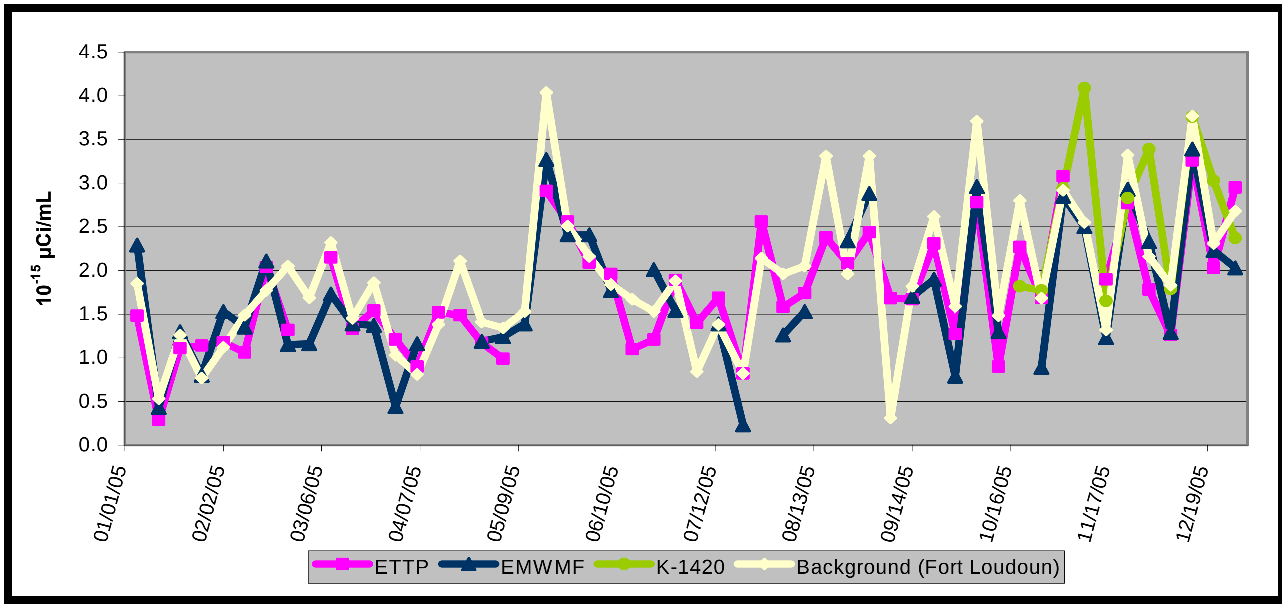

Figure 1: 2005 Gross Alpha Results from Fugitive Air Monitoring Performed at ETTP (Northeast of the K-25 Process Building), ETTP's K-1420 Decontamination and Uranium Recovery Facility, the EMWMF, and the Background Location at Fort Loudoun Dam

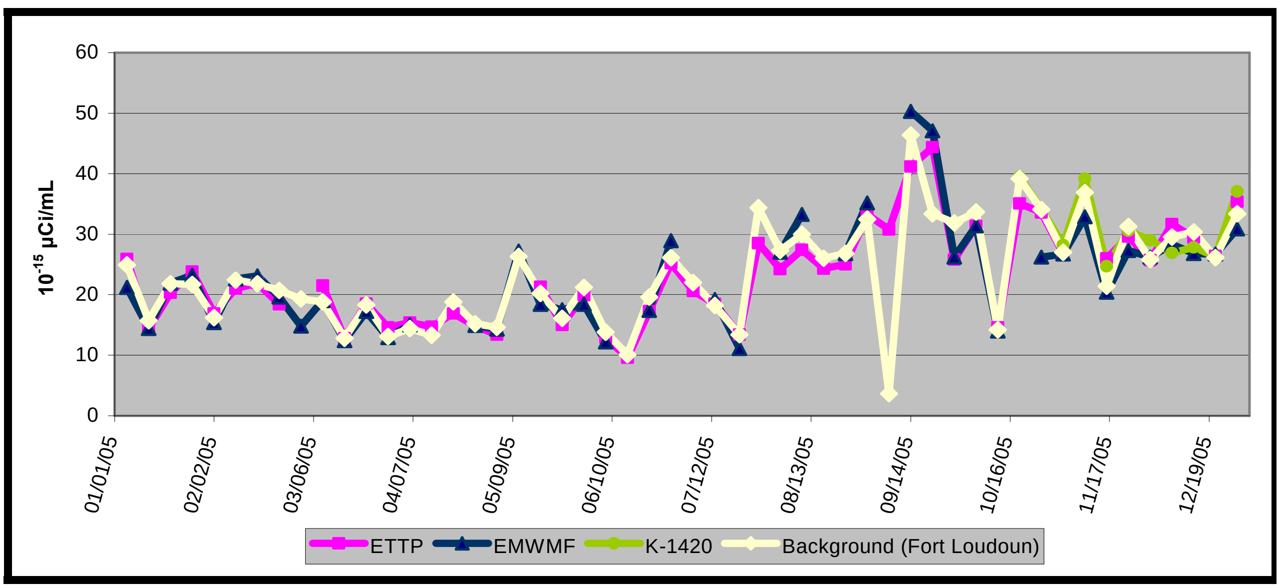

Figure 2: 2005 Gross Beta Results from Fugitive Air Monitoring Performed at ETTP (Northeast of the K-25 Process Building), ETTP's K-1420 Decontamination and Uranium Recovery Facility, the EMWMF, and the Background Location at Fort Loudoun Dam

2005 Results vs. CAA Standards

The CAA specifies that exposures to the public from radioactive materials released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem in a year above background measurements. Compliance with this standard is generally determined for point source emissions that employ air dispersion models to predict the dose at off-site locations. However, the CAA also provides environmental concentrations for radionuclides equivalent to a dose of 10 mrem in a year. Staff use these concentrations to assess the compliance of the emissions measured with the CAA dose limit.

Because the hazards associated with the various radionuclides differ significantly, the CAA requires specific analysis for each isotope determined to be of concern. Consequently, the CAA standards do not include limits for gross alpha and beta activities. Nevertheless, the more economical gross measurements, when treated as surrogates for the more hazardous isotopes, provide an effective screening mechanism to determine if further evaluation is warranted. The standards used in the program to screen the data are those of uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter). Both have relatively restrictive limits and both are routinely encountered on the reservation. It should be understood that it is very unlikely that these isotopes would be responsible for a major proportions of the gross activities reported.

Figures 3 and 4 show the average activity for gross alpha and beta measured during the year 2005 at ETTP (northeast of the K-25 facility), the EMWMF, and the background station. The CAA environmental standards for uranium-235 and strontium-90 are provided for comparison. The standards apply to the dose above background, so the limit represented in Figure 3 and 4 have been adjusted to include the average of gross alpha/beta measurement taken at the background station.

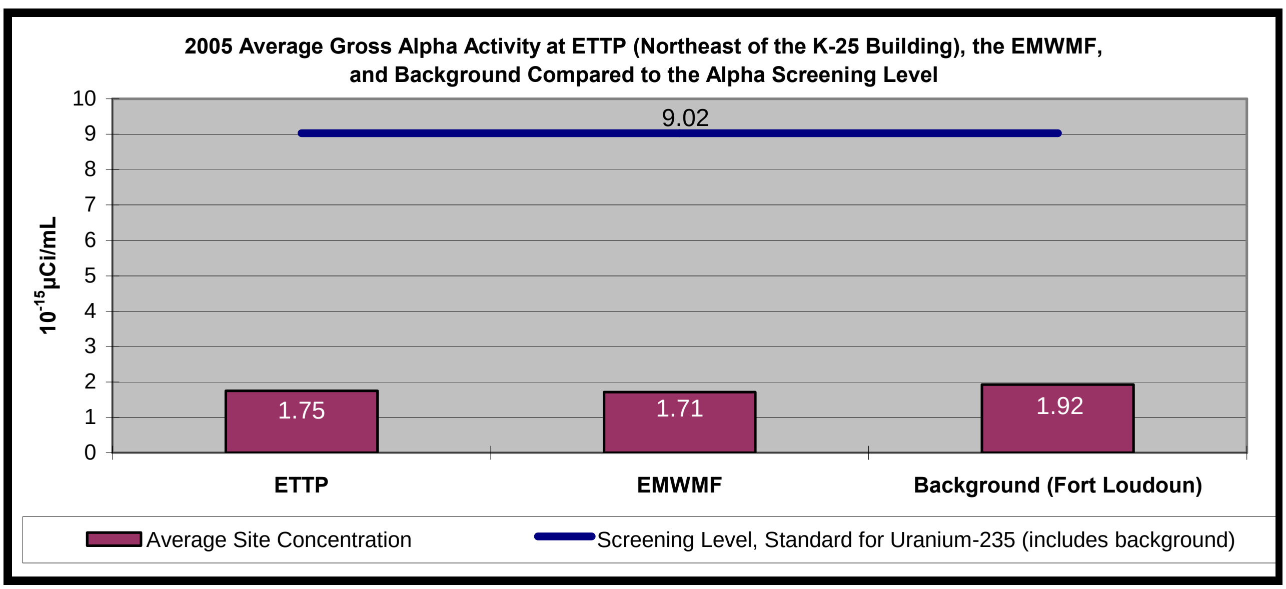

Figure 3: 2005 Average Gross Alpha Activities Measured at ETTP (Northeast of the K-25 Building), the EMWMF, and Fort Loudoun Dam Compared to the CAA Standard for Uranium-235

Note: -The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include background measurements taken during the same period.

-The CAA's Environmental Limit for uranium-235 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

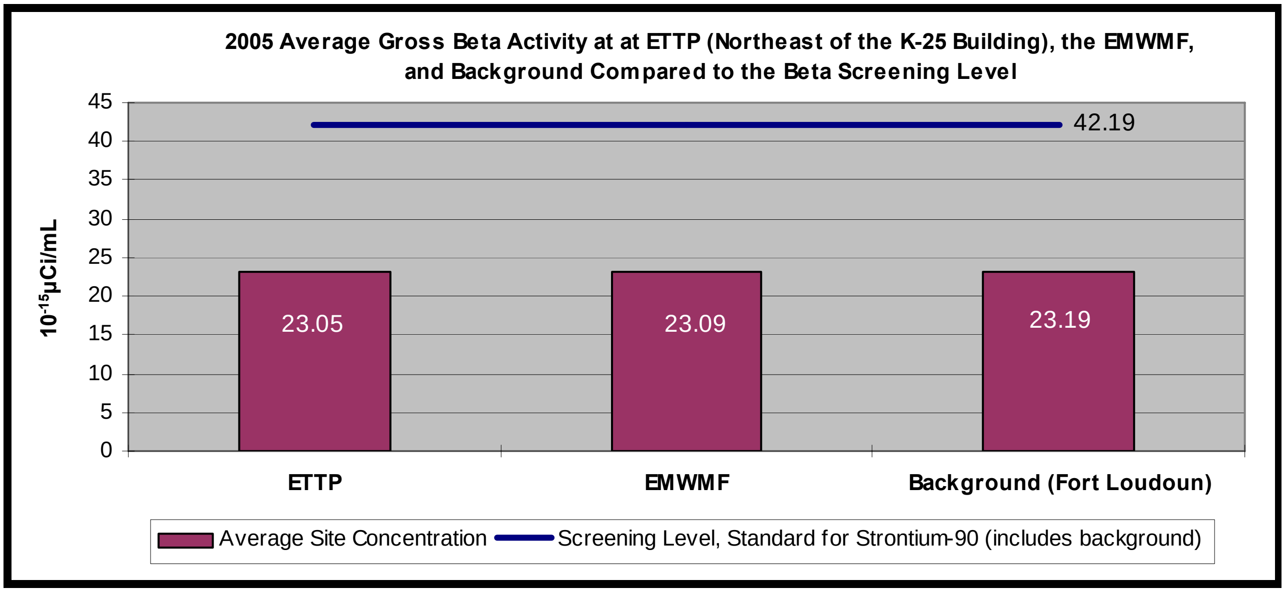

Figure 4: 2005 Average Gross Beta Activity Measured at ETTP (Northeast of the K-25 Building), the EMWMF, and Fort Loudoun Dam Compared to the CAA Standard for Strontium-90

Note: -The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include background measurements taken during the same period.
-The CAA's Environmental Limit for strontium-90 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

Monitoring at the K-1420 Decontamination and Uranium Recovery Facility only occurred for a portion of year (October 19-December 28). To provide a more meaningful representation of the data, Figures 5 and 6 provide the average concentrations measured at the K-1420 Facility and the average results for background measurements taken during the same time period. As might expected, the results for the K-1420 facility are similar, but slightly higher than the background measurements.

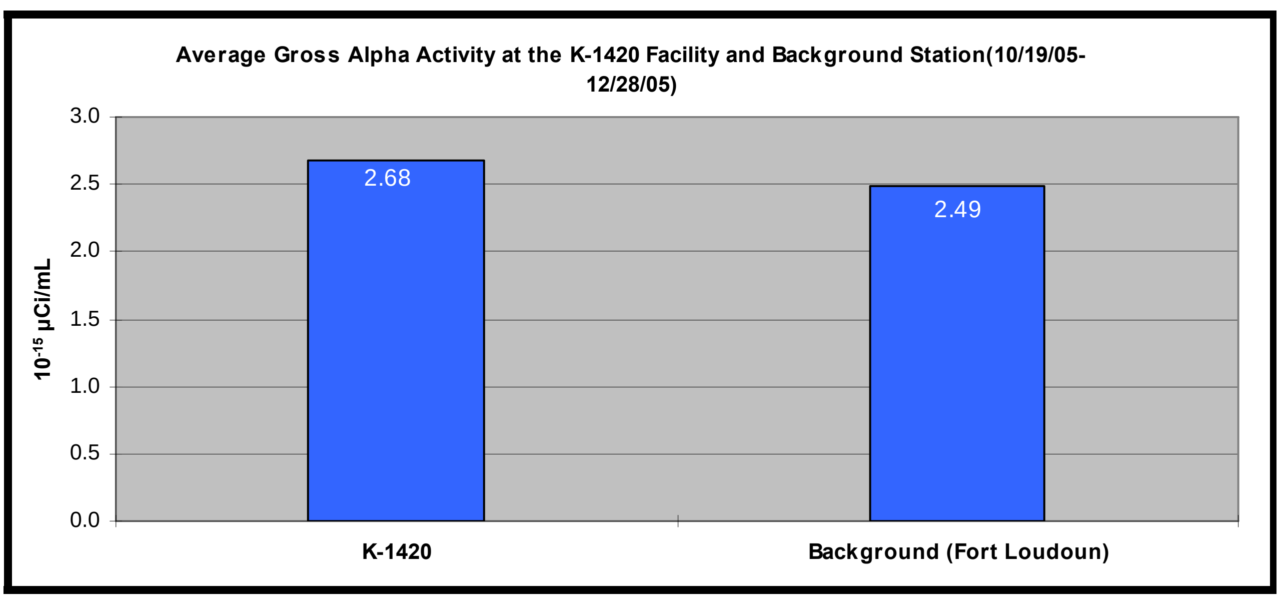

Figure 5: Average Gross Alpha Activity Measured at the K-1420 Decontamination and Uranium Recovery Facility and the Background Location from 10/19/05-12/28/05

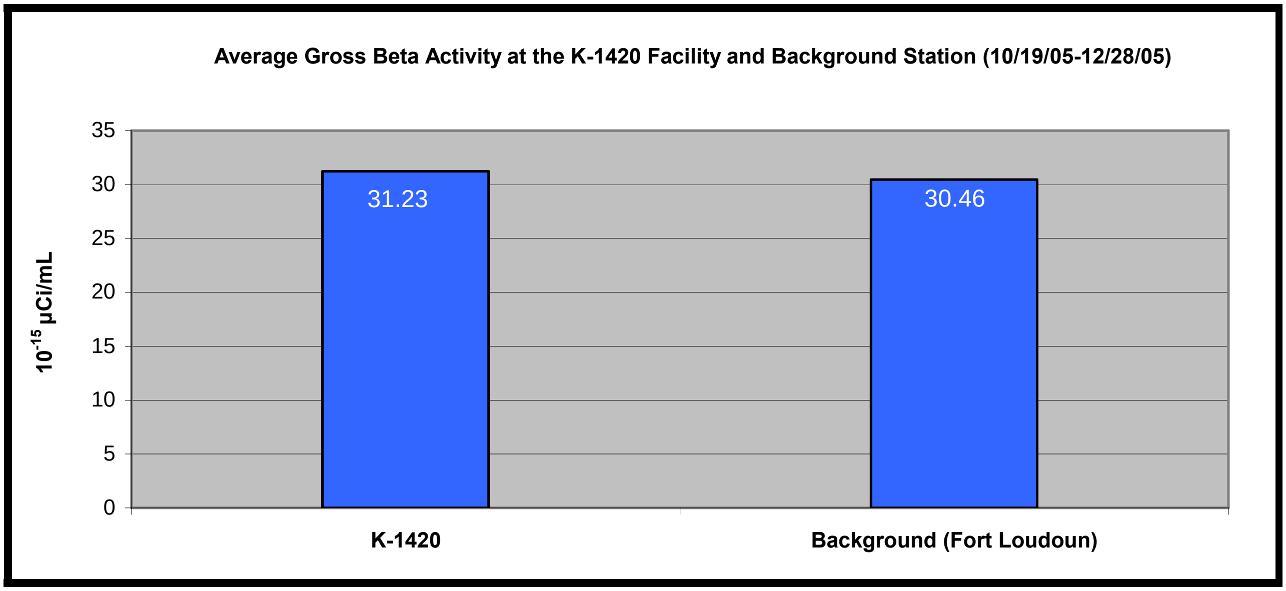

Figure 6: Average Gross Beta Activity Measured at the K-1420 Decontamination and Uranium Recovery Facility and Background Location from 10/19/05-12/28/05

Conclusion

Results for fugitive air monitoring performed at the EMWMF, ETTP (northeast of the K-25 Facility), and ETTP's K-1420 Decontamination and Uranium Recovery Faculty in 2005 fluctuated somewhat, but remained near background levels and below screening levels used to assess compliance with Clean Air Act Standards.

References

Department of Energy (DOE), 2003. *2003 Remedial Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*. DOE/ORO/01-2058&D1. Prepared for DOE by Science Applications International Corporation (SAIC). March 2003.

Department of Energy (DOE), 2005. *2005 Remedial Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*. DOE/ORO/01-2211&D2. Prepared for DOE by Science Applications International Corporation (SAIC). August 2005.

Environmental Protection Agency (EPA), 1994. *Clean Air Act*. 40 CFR Part 61, Subpart H. National Emissions Standards for Hazardous Air Pollutants (NESHAPS).

National Council on Radiation Protection and Measurements (NCRP). 1985. *Environmental Radiation Measurements.* NCRP report No. 50. August 1, 1985.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the Department of Energy and the State of Tennessee*. 2001. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation (TDEC), 2004. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Environmental Monitoring Plan January through December* 2005. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, 2005. *Tennessee Department of Environment and Conservation, DOE Oversight Division Environmental Monitoring Report January through December 2004.* Oak Ridge, Tennessee.

Thomasson, D.A. 2005. *Health, Safety and Security Plan.* Tennessee Department of Environment and Conservation. Department of Energy Oversight Division. Oak Ridge, Tennessee.

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CHAPTER 1 AIR QUALITY MONITORING

The RadNet Air Monitoring Program (formerly the Environmental Radiation Ambient Monitoring System)

Principal Authors: Natalie Pheasant, Howard Crabtree

Abstract

In 2005, the Environmental Protection Agency changed the name of its Environmental Radiation Ambient Monitoring System to RadNet to reflect upgrades planned for the program and internet access to associated data. The program provides radiochemical analysis of air samples taken from five air monitoring stations located on the Oak Ridge Reservation. These samples are collected by personnel from the Tennessee Department of Environment and Conservation and analysis is performed at EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. The results are provided to the state and are available at the RadNet website. In 2005, data for the five RadNet air monitors exhibited similar trends and concentration. While slightly higher results were reported at monitoring locations near the Y-12 National Security Complex, the results for 2005 do not indicate a significant impact on the environment or public health from ORR emissions.

Introduction

In the past, air emissions from DOE activities on the Oak Ridge Reservation (ORR) were believed to have been a potential cause of illnesses affecting area residents. While these emissions have substantially decreased over the years, concerns have remained that air pollutants from current activities (e.g., incineration of radioactive wastes, production of radioisotopes, and remedial activities) could pose a threat to public health and/or the surrounding environment. As a consequence, the Tennessee Department of Environment and Conservation (TDEC) implemented three air monitoring programs to assess the impact of ORR air emissions on the surrounding environment and the effectiveness of DOE controls and monitoring systems.

TDEC's Perimeter and Fugitive Air Monitoring Programs (described in associated reports) focus on monitoring exit pathways, non-point sources of emissions, and sites of special interest. TDEC's participation in the Environmental Protection Agency's (EPA) Environmental Radiation Ambient Monitoring System (ERAMS) has supplemented the other programs and provided verification of state and DOE monitoring. In 2005, EPA changed the name of its ERAMS program to RadNet to reflect upgrades planned for the program and Internet access to associated data, although substantial changes to the ORR program are not anticipated in the near future.

Methods and Materials

The approximate locations of the five RadNet air samplers are provided in Figure 1 and EPA's analytical parameters are listed Table 1. The RadNet air samplers run continuously, collecting suspended particulates on synthetic fiber filters (ten centimeters in diameter) as air is drawn through the units at approximately thirty-five cubic feet per minute by a pump. TDEC staff collect the filters from each sampler twice weekly, estimate the radioactivity on each using TDEC detection equipment and protocol specified by EPA, then ship the filters to EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama, for analysis.

NAREL performs gross beta analysis on each sample collected. Where the gross beta result exceeds one picocurie per meter cubed (pCi/m^3), additional analysis (gamma spectrometry) is performed to identify gamma emitters that may be present in the sample. Analysis for uranium and plutonium isotopes is performed annually on a composite of the air filters collected during year. The results of the NAREL analysis are provided to TDEC staff and published in quarterly reports (*Environmental Radiation Data*), which are available on NAREL's Internet web site (http://www.epa.gov/narel/radnet/erdonline.html).

In 2005, none of the gross beta results reported for the program exceeded the NAREL screening level that would have required analysis by gamma spectrometry. The 2005 results for uranium and plutonium analysis performed annually on composites of the air filters for each monitoring station were not available at the time of this report.

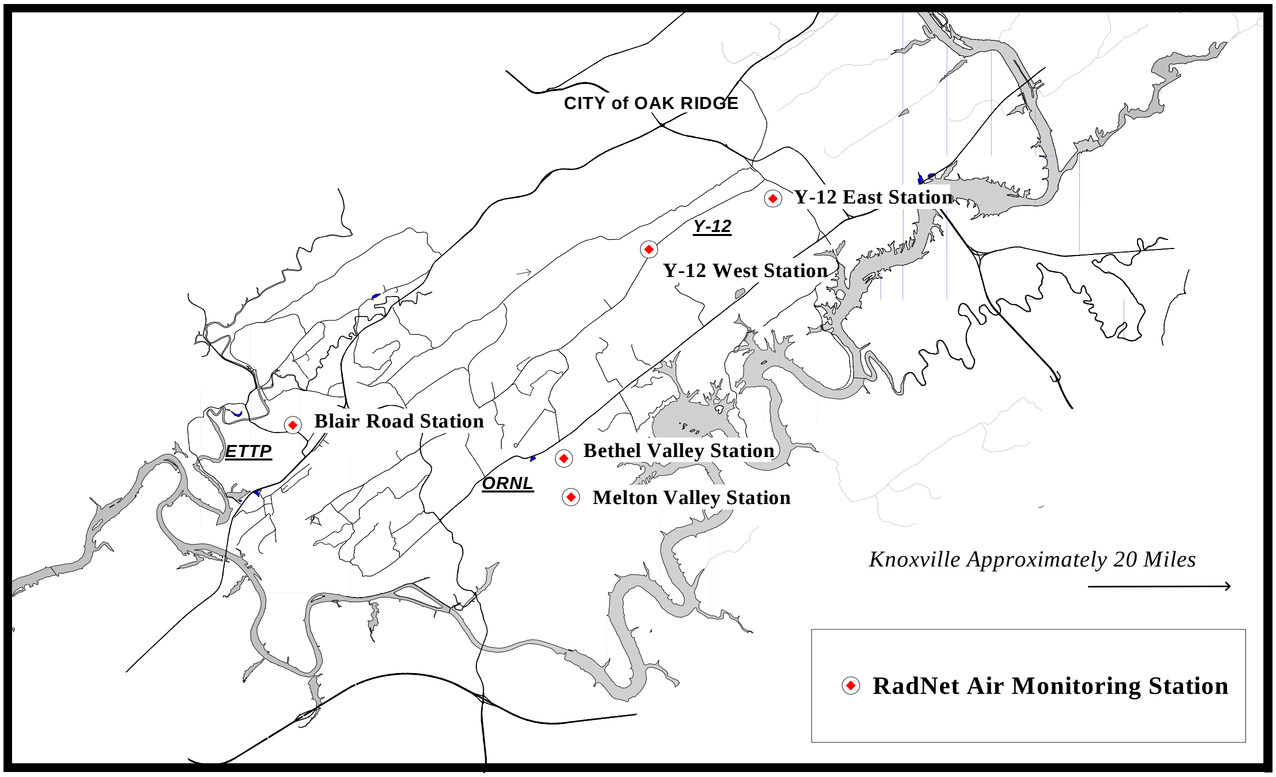

Figure 1: Approximate Locations of Air Stations Monitored on the Oak Ridge Reservation in Association with EPA's RadNet Air Monitoring Program

Table 1: EPA Analysis of Air Samples Taken in Association with EPA's RadNet Program

ANALYSIS	FREQUENCY
Gross Beta	Each sample, twice weekly
Gamma Scan	Samples showing greater than 1 pCi/m^3 of gross beta
Plutonium-238, Plutonium-239, Plutonium-240, Uranium-234, Uranium-235, Uranium-238	Annually on a composite of the filters from each station

Results and Discussion

As can be seen in Figure 2, the results for the gross beta analysis in 2005 were very similar for each of the ORR RadNet monitoring stations and nearly all were lower than the results reported for the Fugitive Air Monitoring Program background station (at Fort Loudoun Dam in Loudon County). While it is not uncommon for concentrations to be less on the ORR than at the background station, data reported for the RadNet/ERAMS stations has consistently been lower than the results reported for the Fugitive and Perimeter Monitoring Programs. This tendency can be observed in Figure 3. The slight bias is believed to be an artifact of the different sampling equipment and monitoring frequency used in the RadNet/ERAMS program. The fluctuations in the results in Figure 2 are largely attributable to natural phenomena (e.g., wind and rain) that influence the amount of particulates suspended in the air and thus what is ultimately deposited on the filters.

The results for the RadNet program were higher overall for the two stations immediately adjacent to the Y-12 National Security Complex (i.e., stations Y-12 East and Y-12 West). It is probable these slightly higher results are associated with Y-12's campaign to modernize operational facilities and tear down unneeded buildings, but the exact cause is unknown.

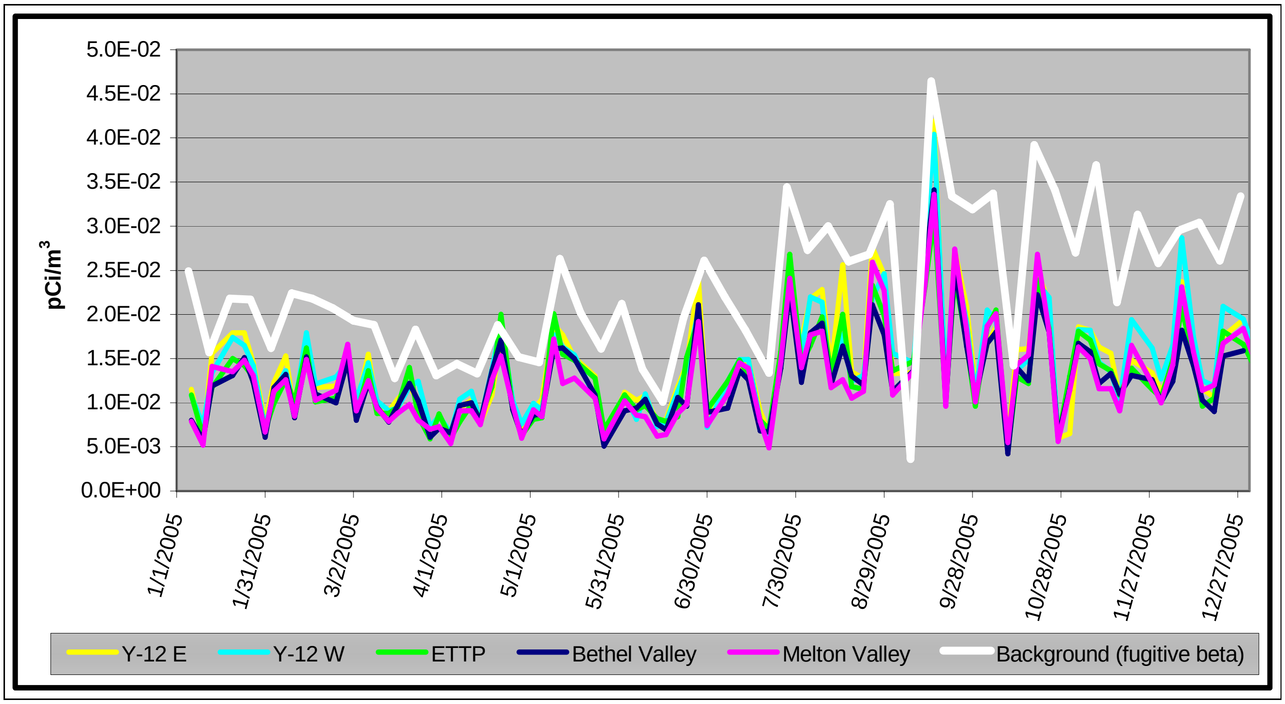

Figure 2: 2005 Gross Beta Results from Air Samples taken on the ORR in Association with EPA's RadNet Air Monitoring Program and Background Measurements Taken in the Division's Fugitive Air Monitoring Program

Figure 3 depicts (1) the 2005 average gross beta results for each station in the ORR RadNet Program, (2) the average background concentration measured at Fort Loudoun Dam by the division's Fugitive Air Monitoring Program, and (3) the Clean Air Act (CAA) environmental limit for strontium-90.

The CAA specifies that exposures to the public from radioactive materials released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem in a year. The CAA specifies environmental concentrations for specific radionuclides that would be equivalent to this dose limit, but does not provide a standard for gross measurements. To evaluate the RadNet data, staff compare the gross beta results reported for the program to the CAA limit for strontium-90, which has one of the most stringent standards of the beta emitting radionuclides. The standards apply to the dose above background, so the limit represented in Figure 3 has been adjusted to include the average gross beta measurement taken at the background station for the Fugitive Air Monitoring Program. It should be understood that strontium-90 is unlikely to be a large contributor to the total beta measurements reported here and is used only as a reference point to determine if further analysis is justified.

As can be seen in Figure 3, the average results for the Y-12 East and Y-12 West monitoring stations are slightly higher than the remaining stations, but each of the RadNet monitoring stations fall well below the strontium-90 limit.

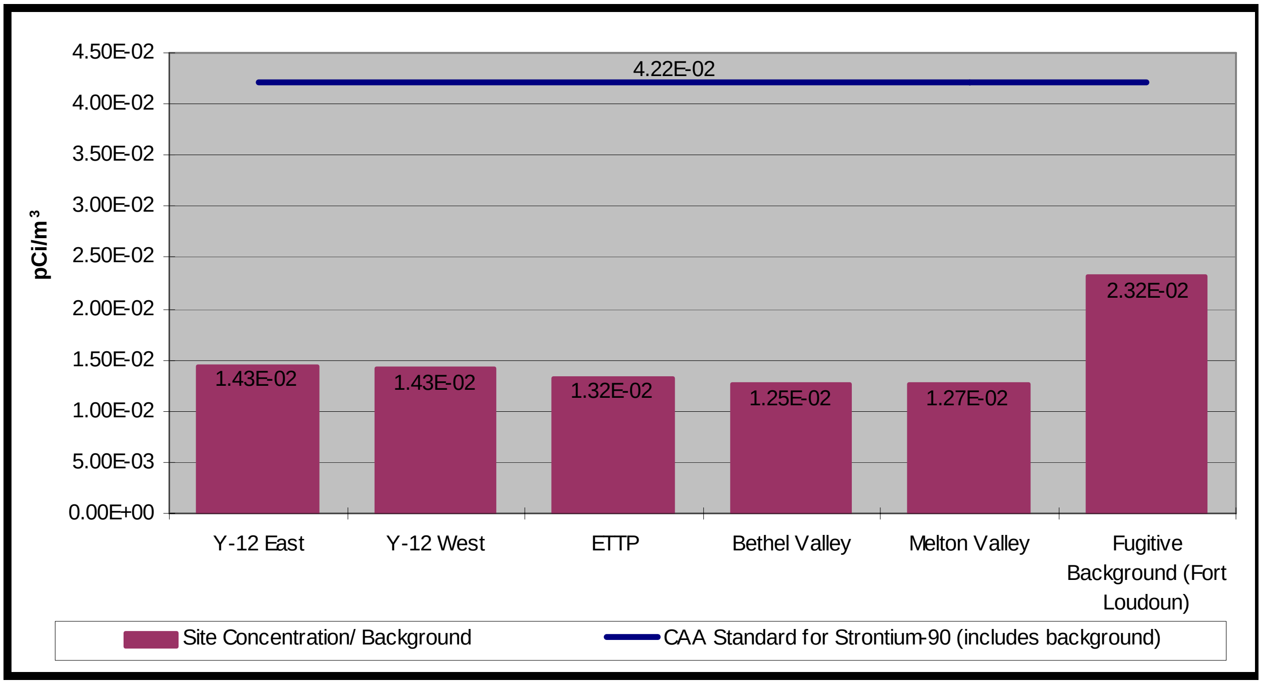

Figure 3: 2005 Average Gross Beta Results for Air Samples Taken on the ORR in Association with EPA's RadNet Air Monitoring Program

Note: Typical Background values for gross beta range from 0.005- 0.1 pCi/m^3 (ORISE, 1993)
-The standards provided by the Clean Air Act apply to the dose above background; therefore, the standard provided for reference in this figure has been adjusted to include the background measurements taken from the division's Fugitive Air Monitoring Program during the same period.
- The CAA's Environmental Limit for strontium-90 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

Conclusion

As in the past, the gross beta results for each of the five RadNet/ERAMS air monitoring stations exhibited similar trends and concentrations. While slightly higher results were reported at monitoring locations near the Y-12 National Security Complex, the available RadNet data for 2005 do not indicate a significant impact on the environment or public health from ORR emissions.

References

Bechtel Jacobs Co. LLC, 2002. *Investigation Report of the Strontium Contamination Event at Oak Ridge National Laboratory, Oak Ridge, Tennessee*. BJC/OR-1172. September 13, 2002.

Oak Ridge Institute for Science and Education (ORISE). 1993. *Environmental Air Sampling.* Hand Out from Applied Health Physics Course (PWF: jb). June 8, 1993.

Tennessee Department of Environment and Conservation, 2004. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division Environmental Monitoring Plan January through December 2005*. December 2004. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the Department of Energy and the state of Tennessee*. Oak Ridge, Tennessee.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

U.S. Environmental Protection Agency (EPA), 1988. *Environmental Radiation Ambient Monitoring System (ERAMS) Manual*. EPA 520/5-84-007, 008, 009. May 1988.

U.S. EPA. 1994. *Environmental Radiation Data Report 80*. EPA-402-R-97-004. February, 1997.

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CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

Benthic Macroinvertebrate Biomonitoring Using a Semi-Quantitative Approach: Rapid Bioassessment Protocol (RBP III)

Principal Author: Randy Hoffmeister

Abstract

The biotic integrity of streams originating on the Oak Ridge Reservation (ORR) was determined by collecting semi-quantitative benthic macroinvertebrate samples from study sites in four aquatic systems impacted by Department of Energy (DOE) operations. Two streams not previously examined were sampled for qualitative purposes. Samples were collected and processed following the state of Tennessee standard operating procedures for macroinvertebrate surveys. Generated data was analyzed using applicable metrics. An assessment score was calculated from the metrics and a site rating was assigned. Results indicate the biotic integrity in all four systems is less than optimal compared to reference conditions. Continued benthic macroinvertebrate monitoring is necessary to provide a more thorough and accurate assessment of stream conditions. The effectiveness of DOE remedial activities can be assessed with long term monitoring efforts.

Introduction

Benthic macroinvertebrates are organisms that inhabit the bottom substrates of aquatic systems. Examples include insects, crustaceans, annelids, and mollusks. Because of their relatively long life spans and sedentary nature, benthic macroinvertebrate community structure can be useful in assessing the biological integrity of streams. A continuous biomonitoring program is a proven method of assessing and documenting any changes that may occur within the impacted system.

Historically, four aquatic systems originating on the Oak Ridge Reservation: East Fork Poplar Creek, Bear Creek, Mitchell Branch, and the White Oak Creek/Melton Branch watershed have been impacted by DOE related activities. East Fork Poplar Creek and Bear Creek have received inputs from the Y-12 Plant, Mitchell Branch from the East Tennessee Technology Park (ETTP), and the White Oak Creek/Melton Branch watershed from the Oak Ridge National Laboratory (ORNL). Benthic macroinvertebrate samples were collected from various locations on these streams for semi-quantitative analysis. Surface water samples were collected at the sites and analyzed for various constituents in support of the biomonitoring. Parameters analyzed included: nutrients, microbiologicals (E. Coli and Enteroccocus), mercury, metals, hardness, residue, and radiological constituents. Benthic macroinvertebrate samples were also collected from offsite locations on Scarboro Creek and Ernie's Creek. Although these two streams do not originate on the ORR, they were identified as potential receiving streams and were incorporated into the sampling program for qualitative assessments. The objectives of this study were to quantify benthic macroinvertebrate communities and to assess the degree of impact compared to reference conditions.

Method and Materials

Benthic macroinvertebrate communities were semi-quantitatively and qualitatively sampled between April 27, 2005, and May 5, 2005, using the Tennessee Department of Environment and Conservation Division of Water Pollution Control *Quality System Standard Operating Procedure* (SOP) *for Macroinvertebrate Stream Surveys.* Depending on stream size, either a one square meter kick net (for larger streams) or a D-frame stationary net (for smaller streams) was used to collect benthic macroinvertebrates. In larger streams, two separate riffle kicks were performed by a two-person crew. One individual held the double handle kick net perpendicular to the current with the net's weighted bottom resting firmly on the streambed. Another person disrupted the substrate with a kicking and sweeping motion in a one square meter stretch just upstream of the net. Benthic organisms were dislodged and drifted into the waiting net. After allowing suitable time for all the debris to flow into the net, the person performing the kick lifted the bottom of the net at each end in a smooth, continuous motion while the person holding the net at the top was careful not to let the top edge dip below the water's surface. After a second riffle was sampled in an identical fashion, the collected organisms were picked from the net and transferred into a container as a composite sample.

At smaller stream sites (e.g., Bear Creek BCK 12.3), where riffles were less than one meter wide, four separate riffle kicks were performed using the one-man, D-frame net. A crewmember held the single handle net perpendicular to the current with the net's bottom pressed firmly to the streambed. The same person disrupted the upstream substrate for an 18-inch distance and the width of the net, dislodging any benthic organisms. After allowing suitable time for all debris to drift into the net, the net was lifted from the water and three additional riffles were sampled in the same fashion. The debris from all four kicks was composited.

Benthic macroinvertebrate samples were preserved in 80% ethanol with internal and external site specific labels. Labeling information included site name, sampling date, and sampler's initials. If more than one sample container was needed at a site, the debris was split evenly with internal and external labels completed for each container.

Sample collection methods were modified in the White Oak Creek watershed due to the presence of radioactive contamination in the stream sediments. The two, 1-meter kick samples were combined in a 5-gallon bucket, creek water was added and the sample swirled to suspend the lighter material (including invertebrates) with the elutriate then being poured through a sieve. This process was repeated five times to ensure the thorough collection of organisms. Any material not needed was returned to the creek. Samples from radioactively contaminated sites were processed in laboratory space designated by ORNL Health Physics personnel.

Once semi-quantitative sampling was completed, sample containers were transported to the State Biology Laboratory in Nashville for processing. Following the State SOP for laboratory sample processing, samples were sorted and benthic macroinvertebrates were enumerated and identified to the genus level. Biological metrics were calculated from the raw data in order to develop an overall site assessment rating. Calculated metrics included Taxa Richness, EPT (Ephemeroptera, Plecoptera, Trichoptera) Richness, Percent EPT, Percent OC (oligochaetes and chironomids), NCBI (North Carolina Biotic Index), Percent Dominant Taxon, and Percent Clingers. Once values were obtained for the seven metrics, a score of 0, 2, 4, or 6 was given to each metric based on comparison to the metric target values for Bioregion 67F, the reference ecoregion for Oak Ridge Reservation streams. The seven scores were totaled and the overall index score (IS) was compared to the Target Index Score (TIS) for Bioregion 67F, TIS = 32. The biological condition rating of the sampling site was estimated within a range of Non-Supporting/Severely Impaired (IS < 10) to Supporting/Non-Impaired (IS >= 32).

Samples from Scarboro Creek and Ernie's Creek were processed in-house following the State SOP for qualitative analysis. Three metrics: Taxa Richness, Number of EPT, and Number of Intolerant

Taxa, were calculated based on family level identifications. A score of 1, 3, or 5 was assigned to each metric based on comparison to the metric target values for Bioregion 67F. The three scores were totaled to determine the overall scoring value. A Severely Impaired (partially or not supporting system) assessment was given if the overall score was 5 or less. A score of 6-10 indicated the results were ambiguous and additional data was needed. The site was considered Non-impaired (supporting) if the score was 11-15. A description of the metrics and the equations used to calculate them can be obtained by referencing the state SOP. The biometrics used to generate stream ratings and the expected response of each metric to stress introduced to the system are presented in Table 1.

Table 1. Description of Metrics and Expected Responses to Stress

Category	Metric	Description	Response to Stress
Richness Metrics	Number of taxa	Measures the overall variety of the macroinvertebrate assemblage	number decreases
	Number of EPT taxa	Number of taxa in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	number decreases
	Number of Intolerant taxa	Number of taxa in the families listed in State SOP as being intolerant to stress (NCBI between 0.00 and 3.00)	number decreases
Composition Metrics	% EPT	% of Ephemeroptera, Plecoptera, and Trichoptera	% decreases
	% OC	% of oligochaetes (worms) and chironomids (midges)	% increases
Tolerance Metrics	% Dominant	% contribution of single most dominant taxa	% increases
	NCBI	North Carolina Biotic Index which incorporates richness and abundance with a numerical rating of tolerance	number increases
Habit Metric	% Clingers	% of macroinvertebrates having fixed retreats or attach to surfaces	% decreases

<u>Results and Discussion</u>

Semi-quantitative Assessments

<u>East Fork Poplar Creek</u>

The metric values, metric scores, overall index scores, and biological condition ratings of the impacted streams on the ORR are presented in Table 2. EFK 25.1 (IS=20), EFK 24.4 (IS=18), EFK 23.4 (IS=18), and EFK 6.3 (IS=16) rated partially supporting/moderately impaired compared to Bioregion reference conditions. The biotic integrity appeared to improve at EFK 13.8 (IS=26) with a partially supporting/slightly impaired rating. Taxa Richness and %EPT decreased with distance from the Plant suggesting degraded conditions downstream. Conditions at EFK 13.8 appeared to improve with a decrease in %OC and an increase in the Taxa Richness and %EPT. Results indicate an upstream trend of increasing biotic integrity in East Fork Poplar Creek. Despite the appearance of relatively good conditions upstream, East Fork Poplar Creek continued to show signs of impaired conditions with index scores well below the target index score. Surface water results (Appendix 1) show mercury levels remain elevated in East Fork Poplar Creek compared to other ORR streams.

<u>Mitchell Branch</u>

Despite having the same condition ratings, the biotic integrity in Mitchell Branch appeared to decrease with distance through ETTP based on individual metric scores. MIK 0.71 and MIK 0.45, located inside the Plant, had lower Taxa and EPT Richness values compared to the upstream reference site, MIK 1.43 (Table 2). A 75% decrease in Percent EPT coupled with a 35% increase in the Percent OC at MIK 0.71 suggests Plant related impacts downstream. The amount of suitable habitat in lower Mitchell Branch, especially in the remediated portion near MIK 0.71, along with impacts from source pollutants within ETTP continue to limit the composition of benthic macroinvertebrates. Appendix 1 shows results from surface water samples taken in Mitchell Branch.

White Oak Creek and Melton Branch

Table 2 shows ratings in White Oak Creek improved from partially supporting, slightly impaired to supporting, non-impaired with distance from the reference site, WCK 6.8. Stream conditions appeared to favor the more sensitive organisms (mayflies, stoneflies, and caddisflies) as %EPT more than doubled from 38% at WCK 6.8 to 86% downstream at WCK 3.4. %Oligochaetes and Chironomids, organisms that tend to dominate stressed environments, decreased 80% over the same distance. Suppressed %EPT and relatively high %OC at WCK 6.8 suggest impaired conditions may exist. The use of this site as a reference location for lower White Oak Creek may need to be addressed. Further assessments can be made through continued sampling and documentation of changes in the benthic community.

Melton Branch was sampled for the first time since remedial action occurred in the stream. From Table 2, metric values at MEK 0.3 mirror those in lower White Oak Creek. Results from continued sampling at this site will be useful in assessing the effectiveness of ORNL remedial activities. Surface water results from samples taken in White Oak Creek and Melton Branch are reported in Appendix 1.

Bear Creek

Results indicate operations at the Y-12 Plant impact stream conditions in Bear Creek. Relatively low Taxa Richness and high %OC, especially at the uppermost site, suggest degraded conditions exist. %EPT values of 16% at BCK 12.3 and 14% at BCK 9.6 (Table 2) support the assessments of partially supporting, impaired systems. Like Mitchell Branch, the amount of suitable habitat appears to limit benthic macroinvertebrate community assemblages, especially at BCK 12.3. Nutrient levels in surface water samples (Appendix 1) exceeded the State's interpretation of the narrative nutrient criteria for fish and aquatic life.

Qualitative Assessments

Sampling efforts in Scarboro Creek led to ambiguous results (score=7). Based on family level identifications, Taxa Richness = 16, Number of EPT = 5, and Number of Intolerant Taxa = 2. Additional data is needed to provide an accurate assessment of biotic integrity. Ernie's Creek rated severely impaired, partially or not supporting (score=5): Taxa Richness = 12, Number of EPT = 3, and Number of Intolerant Taxa = 1. Continued sampling at these two sites will provide more thorough and accurate assessments.

Table 2. Metric Values, Scores, and Biological Condition Ratings for ORR streams, Spring 2005.

	East Fork Poplar Creek					Mitchell Branch		
METRIC	EFK 25.1	EFK 24.4	EFK 23.4	EFK 13.8	EFK 6.3	MIK 1.43	MIK 0.71	MIK 0.45
Taxa Richness	27 (4)	24 (4)	19 (2)	29 (4)	23 (4)	42 (6)	34 (6)	33 (6)
EPT Richness	4 (2)	4 (2)	4 (2)	3 (0)	2 (0)	5 (2)	4 (2)	3 (0)
% EPT	11.4 (0)	10.0 (0)	5.3 (0)	27.9 (2)	14.1 (0)	19.6 (2)	5.0 (0)	5.2 (0)
% OC	81.1 (0)	82.0 (0)	84.6 (0)	63.5 (2)	79.9 (0)	64.1 (2)	86.6 (0)	60.1 (2)
NCBI	5.38 (4)	4.86 (4)	5.31 (4)	4.30 (6)	4.80 (4)	4.18 (6)	5.09 (4)	4.75 (6)
% Dominant	49.1 (4)	41.0 (4)	51.0 (4)	33.2 (6)	21.1 (6)	10.9 (6)	29.2 (6)	19.2 (6)
% Clingers	64.6 (6)	51.0 (4)	63.5 (6)	56.3 (6)	33.7 (2)	10.3 (0)	39.1 (4)	40.4 (4)
INDEX SCORE	20	18	18	26	16	24	22	24
RATING	**C**	**C**	**C**	**B**	**C**	**B**	**B**	**B**

	White Oak Creek					Bear Creek	
METRIC	WCK 6.8	WCK 3.9	WCK 3.4	WCK 2.3	MEK 0.3	BCK 12.3	BCK 9.6
Taxa Richness	30 (4)	21 (4)	14 (2)	27 (4)	23 (4)	22 (4)	18 (2)
EPT Richness	7 (2)	5 (2)	4 (2)	5 (2)	6 (2)	4 (2)	5 (2)
% EPT	38.3 (4)	63.1 (6)	85.7 (6)	66.9 (6)	64.2 (6)	16.0 (2)	14.0 (0)
% OC	48.6 (4)	19.9 (6)	9.0 (6)	25.8 (6)	32.6 (4)	74.6 (2)	9.5 (6)
NCBI	3.76 (6)	4.94 (4)	5.27 (4)	4.30 (6)	3.93 (6)	4.66 (6)	5.89 (4)
% Dominant	14.3 (6)	35.9 (4)	50.8 (4)	33.5 (6)	30.3 (6)	23.8 (6)	52.0 (4)
% Clingers	27.4 (2)	53.9 (4)	61.4 (6)	44.9 (4)	62.8 (6)	26.0 (2)	30.5 (2)
INDEX SCORE	28	30	30	34	34	24	20
RATING	**B**	**B**	**B**	**A**	**A**	**B**	**C**

Key:

A - Fully Supporting - Non-impaired……………………………………..	>= 32
B - Partially Supporting - Slightly Impaired……………………………..	21 - 31
C - Partially Supporting - Moderately Impaired…………………………	10 - 20
D - Non-Supporting - Severely Impaired…………………………………	< 10

Conclusions

The biotic integrity of streams on the ORR is less than optimal compared to reference conditions. Two sites, both in the White Oak Creek watershed, showed signs of supporting, non-impaired conditions. The remaining sites had biological condition ratings of partially supporting systems with slight to moderate impairment. The amount of suitable habitat is likely a key factor in the diversity of benthic communities at MIK 0.71 and BCK 12.3. Surface water sampling results indicated mercury remains persistent in East Fork Poplar Creek and nutrient inputs continue to affect Bear Creek. Monitoring benthic macroinvertebrate communities should provide more thorough and accurate assessments of stream conditions by capturing temporal and spatial changes due to DOE related activities. Environmental remedial actions taken by DOE continue to have an impact on the aquatic environments in East Fork Poplar Creek, Mitchell Branch, the White Oak Creek watershed, and Bear Creek. The effectiveness of remedial activities over time can be monitored by documenting changes in the benthic macroinvertebrate communities.

References

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee.* Oak Ridge, Tennessee. 2001.

Tennessee Department of Environment and Conservation Division of Water Pollution Control Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys, March, 2002. Revised November 2003.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

APPENDIX 1

2005 Semi-Annual Surface Water Sampling Results at Benthic Macroinvertebrate Sampling Sites

		EFK 24.4 (35° 59.368' N latitude, 84° 14.545' W longitude)		**EFK 23.4** (35° 59.759' N latitude, 84° 14.410' W longitude)		
		1	2	1	2	limit
TEST						
E. coli	(CFU/100 ml)	54		42		1
Enterococcus	(CFU/100 ml)	52		9		1
Ammonia	(mg/l)	U	U	U	U	0.02
Dissolved residue	(mg/l)	168		173		10
NO_3 & NO_2 nitrogen	(mg/l)	1.6	0.99	1.7	1	0.01
suspended residue	(mg/l)	U		U		10
total hardness	(mg/l)	143		148		1
total Kjeldahl nitrogen	(mg/l)	0.16	U	0.35	U	0.10
total phosphate	(mg/l)	0.07	U	0.06	U	0.004
sulfate	(mg/l)	25		22		2
arsenic	(ug/l)	U		U		1
cadmium	(ug/l)	U		U		1
chromium	(ug/l)	U		U		1
copper	(ug/l)	4		3		1
iron	(ug/l)	457		434		25
lead	(ug/l)	U		U		1
manganese	(ug/l)	63		53		5
mercury	(ug/l)	0.6	0.3	0.4	0.6	0.2
zinc	(ug/l)	19		17		1
gamma radionuclides	(pCi/L)	NDA		NDA		N/A
Bi-214			75.6		95.1	N/A
Ac-228						N/A
Pb-214			43.8		49.4	N/A
gross alpha	(pCi/L)	11.9	0.8	12.0	3.7	N/A
gross beta	(pCi/L)	6.7	1.9	5.6	3.9	N/A

		EFK 13.8 (35° 59.618' N latitude, 84° 18.859' W longitude)		**EFK 6.3** (35° 57.921' N latitude, 84° 21.091' W longitude)		
		1	2	1	2	limit
TEST						
E. coli	(CFU/100 ml)	80		121		N/A
Enterococcus	(CFU/100 ml)	62		46		N/A
Ammonia	(mg/l)	U	U	U	U	0.02
Dissolved residue	(mg/l)	163		163		10
NO3 & NO2 nitrogen	(mg/l)	1	0.84	1.2	X	0.01
suspended residue	(mg/l)	U		U		10
total hardness	(mg/l)	143		131		1
total Kjeldahl nitrogen	(mg/l)	0.26	U	0.2	U	0.10
total phosphate	(mg/l)	U	U	0.06	U	0.004
sulfate	(mg/l)	18		16		2
arsenic	(ug/l)	U	U	U	U	1
cadmium	(ug/l)	U	U	U	U	1
chromium	(ug/l)	U	1	U	U	1
copper	(ug/l)	U	2	U	2	1
iron	(ug/l)	318	354	366	126	25
lead	(ug/l)	U	U	U	U	1
manganese	(ug/l)	39	85	36	10	5
mercury	(ug/l)	0.2	U	U	0.2	0.2
zinc	(ug/l)	6	5	7	4	1
gamma radionuclides	(pCi/L)	NDA		NDA		
Pb-214			67.2		92.6	N/A
Ti-208						N/A
Bi-214			118.5		114	N/A
Ac-228					16.2	
gross alpha	(pCi/L)	6.2	0	1.7	3.8	N/A
gross beta	(pCi/L)	3.4	3.5	5.1	3.4	N/A

X - Result not reported by Nashville. "Duplicate analysis did not show consistent results."

TEST		MIK 0.71 (35° 56.258' N latitude, 84° 23.266' W longitude) 1	2	MIK 0.45 (35° 56.313' N latitude, 84° 23.401' W longitude) 1	2	limit
E. coli	(CFU/100 ml)	249	172	488	111	N/A
Enterococcus	(CFU/100 ml)	38	86	63	159	N/A
Ammonia	(mg/l)	U	U	U	U	0.02
Dissolved residue	(mg/l)	130	197	135	192	10
NO_3 & NO_2 nitrogen	(mg/l)	0.12	0.18	0.11	0.25	0.01
suspended residue	(mg/l)	U	U	U	U	10
total hardness	(mg/l)	122	199	141	206	1
total Kjeldahl nitrogen	(mg/l)	0.13	X U	U	X U	0.10
total phosphate	(mg/l)	U	X U	U	X U	0.004
arsenic	(ug/l)	U	U	U	U	1
cadmium	(ug/l)	U	U	U	U	1
chromium	(ug/l)	U	U	U	U	1
copper	(ug/l)	1	9	1	5	1
iron	(ug/l)	306	206	268	110	25
lead	(ug/l)	U	U	U	U	1
manganese	(ug/l)	72	97	70	57	5
mercury	(ug/l)	U	U	U	U	0.2
zinc	(ug/l)	8	14	7	4	1
gamma radionuclides	(pCi/L)	NDA		NDA		N/A
Pb-214			25.0		60.6	N/A
Bi-214			59.7		120.0	N/A
Pb-212					10.8	N/A
gross alpha	(pCi/L)	2.5	6.9	10.0	7.2	N/A
gross beta	(pCi/L)	5.7	4.7	3.4	2.4	N/A

MIK 1.43 (35° 56.306' N latitude, 84° 22.575' W longitude)

TEST		1	2	limit
E. coli	(CFU/100 ml)	84	9	N/A
Enterococcus	(CFU/100 ml)	1	39	N/A
Ammonia	(mg/l)	U	U	0.02
Dissolved residue	(mg/l)	55	84	10
NO3 & NO2 nitrogen	(mg/l)	0.21	0.3	0.01
suspended residue	(mg/l)	U	U	10
total hardness	(mg/l)	57	128	1
total Kjeldahl nitrogen	(mg/l)	U	X U	0.10
total phosphate	(mg/l)	U	X U	0.004
arsenic	(ug/l)	U	U	1
cadmium	(ug/l)	U	U	1
chromium	(ug/l)	U	U	1
copper	(ug/l)	U	4	1
iron	(ug/l)	446	298	25
lead	(ug/l)	U	U	1
manganese	(ug/l)	201	197	5
mercury	(ug/l)	U	U	0.2
zinc	(ug/l)	U	1	1
gamma radionuclides	(pCi/L)	NDA		
Pb-214			59.4	
Bi-214			74.9	
Bi-212			42.4	
gross alpha	(pCi/L)	0	0.2	
gross beta	(pCi/L)	3.3	2.1	

X = analyzed outside analytical holding time due to reagent and instrument problems

TEST		WCK 3.9 (35° 55.493' N latitude, 84° 18.931' W longitude) 1	2	WCK 3.4 (35 54.991' N latitude, 84 18.973' W longitude) 1	2	limit
E. coli	(CFU/100 ml)	132		53		N/A
Enterococcus	(CFU/100 ml)	16		35		N/A
Ammonia	(mg/l)	U	0.23	U	U	0.02
Dissolved residue	(mg/l)	159		225		10
NO_3 & NO_2 nitrogen	(mg/l)	0.59	1.04	0.89	1.38	0.01
suspended residue	(mg/l)	U		U		10
total hardness	(mg/l)	146		157		1
total Kjeldahl nitrogen	(mg/l)	U	X 0.82	0.13	X U	0.10
total phosphate	(mg/l)	U	X 0.15	0.1	X 0.17	0.004
arsenic	(ug/l)	U		U		1
cadmium	(ug/l)	U		U		1
chromium	(ug/l)	U		U		1
copper	(ug/l)	5		3		1
iron	(ug/l)	92		171		25
lead	(ug/l)	U		U		1
manganese	(ug/l)	19		18		5
mercury	(ug/l)	U	U	U	U	0.2
zinc	(ug/l)	11		8		1
gamma radionuclides	(pCi/L)					N/A
Bi-212						
Bi-214			60.8	18.5	88.5	N/A
Cs-137		45.5	48.1	63.6	35.1	N/A
Pb-214			34.7	16.6	56.7	N/A
Tl-208					10.2	
gross alpha	(pCi/L)	0.7	6.7	2.8	2	N/A
gross beta	(pCi/L)	87.2	117.1	144.3	101.8	N/A

TEST		WCK 2.3 (35° 54.553' N latitude, 84° 19.146' W longitude) 1	2	MEK 0.3 1	2	limit
E. coli	(CFU/100 ml)	249		157		N/A
Enterococcus	(CFU/100 ml)	44		41		N/A
Ammonia	(mg/l)	U	U	U	U	0.02
Dissolved residue	(mg/l)	279		277		10
NO3 & NO2 nitrogen	(mg/l)	0.74	1.34	0.33	0.29	0.01
suspended residue	(mg/l)	U		U		10
total hardness	(mg/l)	179		224		1
total Kjeldahl nitrogen	(mg/l)	0.1	X U	0.12	X 0.56	0.10
total phosphate	(mg/l)	0.13	X 0.22	0.46	X 0.45	0.004
arsenic	(ug/l)	U		U		1
cadmium	(ug/l)	U		U		1
chromium	(ug/l)	U		U		1
copper	(ug/l)	2		2		1
iron	(ug/l)	172		207		25
lead	(ug/l)	U		U		1
manganese	(ug/l)	43		59		5
mercury	(ug/l)	U	U	U	U	0.2
zinc	(ug/l)	6		6		1
gamma radionuclides	(pCi/L)					N/A
Pb-214			139.6	14.7	65.1	
Bi-214			219.0	15.7	86.6	N/A
Cs-137		38.7	29.8			N/A
gross alpha	(pCi/L)	0	0	0	0	N/A
gross beta	(pCi/L)	275	204	184.8	227	N/A

X = analyzed outside analytical holding time due to reagent and instrument problems

TEST (duplicate values)		**BCK 12.3** (35° 58.480' N latitude, 84° 16.691' W longitude) 1	2	**BCK 9.6** (35 57.616' N latitude, 84 17.799' W longitude) 1	2	limit
E. coli	(CFU/100 ml)	10	157	206 (61)	2419 (2419)	N/A
Enterococcus	(CFU/100 ml)	4	613	31 (66)	1203 (1986)	N/A
Ammonia	(mg/l)	U	U	U (U)	U (U)	0.02
Dissolved residue	(mg/l)	417	1882	179 (182)	395 (395)	10
NO_3 & NO_2 nitrogen	(mg/l)	22.2	25	4.8 (5.0)	13 (13)	0.01
suspended residue	(mg/l)	U	U	U (U)	11 (U)	10
total hardness	(mg/l)	290	1205	161 (161)	356 (361)	1
total Kjeldahl nitrogen	(mg/l)	U	X U	0.18 (U)	XU (XU)	0.10
total phosphate	(mg/l)	U	X U	U (U)	XU (XU)	0.004
arsenic	(ug/l)	U	U	U (U)	U (U)	1
cadmium	(ug/l)	2	3	U (U)	U (U)	1
chromium	(ug/l)	U	U	U (U)	U (U)	1
copper	(ug/l)	U	6	U (U)	5 (4)	1
iron	(ug/l)	265	69	328 (340)	38 (U)	25
lead	(ug/l)	U	U	U (U)	U (U)	1
manganese	(ug/l)	509	448	63 (65)	11 (U)	5
mercury	(ug/l)	U	U	U (U)	U (U)	0.2
zinc	(ug/l)	7	4	3 (3)	2 (2)	1
gamma radionuclides	(pCi/L)	NDA		NDA		N/A
Pb-214			64.1		39.9 (46.1)	N/A
Bi-214			84.8	(12.4-dup)	57.3 (64.5)	N/A
gross alpha	(pCi/L)	70.2	306	15.0 (19.8)	51 (39)	N/A
gross beta	(pCi/L)	72.6	664	16.8 (19.6)	36.8 (40.3)	N/A

TEST		**MBK 1.6** (35° 59.295' N latitude, 84° 17.321' W longitude) 1	2	limit
E. coli	(CFU/100 ml)	47	44	N/A
Enterococcus	(CFU/100 ml)	3	42	N/A
Ammonia	(mg/l)	U	U	0.02
Dissolved residue	(mg/l)	81	163	10
NO_3 & NO_2 nitrogen	(mg/l)	0.1	2.4	0.01
suspended residue	(mg/l)	U	U	10
total hardness	(mg/l)	74	167	1
total Kjeldahl nitrogen	(mg/l)	0.16	X U	0.10
total phosphate	(mg/l)	U	X 0.26	0.004
arsenic	(ug/l)	U	U	1
cadmium	(ug/l)	U	U	1
chromium	(ug/l)	U	1	1
copper	(ug/l)	U	5	1
iron	(ug/l)	285	79	25
lead	(ug/l)	U	U	1
manganese	(ug/l)	47	19	5
mercury	(ug/l)	U	U	0.2
zinc	(ug/l)	1	2	1
gamma radionuclides	(pCi/L)	NDA		N/A
Pb-212			10.2	
Pb-214			65.2	N/A
Bi-214			115.8	N/A
gross alpha	(pCi/L)	0.6 (0.4)	0	N/A
gross beta	(pCi/L)	4.1 (3.4)	3.4	N/A

X = analyzed outside analytical holding time due to reagent and instrument problems

TEST		WCK 6.8 (35° 56.400' N latitude, 84° 18.003' W longitude)		HCK 20.6 (36° 09.461' N latitude, 83° 59.963' W longitude)		
		1	2	1	2	limit
(duplicate values)						
E. coli	(CFU/100 ml)	8 (7)		260	84	N/A
Enterococcus	(CFU/100 ml)	108 (7)		50	649	N/A
Ammonia	(mg/l)	U (U)	U	U	U	0.02
Dissolved residue	(mg/l)	85 (88)		162	216	10
NO_3 & NO_2 nitrogen	(mg/l)	0.11 (0.11)	0.12	0.5	U	0.01
suspended residue	(mg/l)	U (U)		U	U	10
total hardness	(mg/l)	117 (111)		171	229	1
total Kjeldahl nitrogen	(mg/l)	U (U)	X U	0.11	U	0.10
total phosphate	(mg/l)	0.03 (U)	X U	U	U	0.004
sulfate	(mg/l)	X	n/a	7		2
arsenic	(ug/l)	U (U)		U	U	1
cadmium	(ug/l)	U (U)		U	U	1
chromium	(ug/l)	U (U)		U	U	1
copper	(ug/l)	U (U)		U	U	1
iron	(ug/l)	157 (296)		172	125	25
lead	(ug/l)	U (U)		U	U	1
manganese	(ug/l)	27 (43)		34	23	5
mercury	(ug/l)	U (U)	U	U	U	0.2
zinc	(ug/l)	4 (6)		4	3	1
gamma radionuclides	(pCi/L)					
Pb-214		51.8 (33.7)	98.2		87.3	N/A
Bi-214		50.0 (32.4)	177.0	12.0	132.1	N/A
gross alpha	(pCi/L)	2.0 (0.0)	0.2	1.3	0 (0.3)	N/A
gross beta	(pCi/L)	0.8 (0.0)	2.3	0.4	3.6 (1.7)	N/A

TEST		CCK 1.45		
		1	2	limit
E. coli	(CFU/100 ml)	5	83 (36)	N/A
Enterococcus	(CFU/100 ml)	<1	26 (50)	N/A
Ammonia	(mg/l)	U	U (U)	0.02
Dissolved residue	(mg/l)	106	149 (152)	10
NO3 & NO2 nitrogen	(mg/l)	0.5	U (U)	0.01
suspended residue	(mg/l)	U	11 (U)	10
total hardness	(mg/l)	116	168 (165)	1
total Kjeldahl nitrogen	(mg/l)	U	U (U)	0.10
total phosphate	(mg/l)	U	U (U)	0.004
sulfate	(mg/l)	3		
arsenic	(ug/l)	U	U (U)	1
cadmium	(ug/l)	U	U (U)	1
chromium	(ug/l)	U	1 (U)	1
copper	(ug/l)	U	U (U)	1
iron	(ug/l)	25	258 (39)	25
lead	(ug/l)	U	U (U)	1
manganese	(ug/l)	11	68 (13)	5
mercury	(ug/l)	U	U (U)	0.2
zinc	(ug/l)	2	7 (U)	1
gamma radionuclides	(pCi/L)			N/A
Pb-214			56.8 (121.7)	
Bi-214		13.4	56.2 (143.8)	
Pb-212				
Bi-212				
gross alpha	(pCi/L)	0	0 (0)	N/A
gross beta	(pCi/L)	1.5	2.3 (0.1)	N/A

X = analyzed outside analytical holding time due to reagent and instrument problems

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CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

Vascular Plant Surveys (Field Botany)

Principal Author: Gerry Middleton

Abstract

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) staff completed vascular plant field surveys, and conducted oversight of Department of Energy (DOE) botanical fieldwork during 2005 on various project sites on the DOE Oak Ridge Reservation (ORR). Survey sites included wetlands, ORR site access roads (to be widened as fire-breaks), the new waste haul road in west Bear Creek Valley, and the Blackoak Ridge Conservation Easement (BORCE) site near East Tennessee Technology Park (Map 1). Priority was given to locating rare plants and documentation of pest plant invasion areas on the ORR. Division staff also provided botanical support to the TDEC Division of Natural Heritage programs (DNH) including the rare plant program, the natural areas program, and the inventory program. New rare plant locations (previously unrecorded) were identified and mapped on the ORR during 2005, and were documented with DNH.

Introduction

Major goals of the project included: (1) Provide oversight support and local botanical expertise to the TDEC Division of Natural Heritage as needed relating to ORR issues, (2) to inventory and map the biological diversity that exists on the ORR, (3) to provide floristics survey information about plant species on the ORR, (4) to independently monitor and confirm biological survey and sampling information provided by DOE, (5) To protect plants and natural communities that represent biological diversity on the ORR, and (6) Provide flexibility in bio-monitoring the full spectrum of the plant kingdom taxa (both vascular and non-vascular plants) as recognized by the International Code of Botanical Nomenclature (ICBN). Project field surveys were designed to locate and identify rare plant species, exotic pest plant species invasions, plus aquatic, and wetland taxa.

The project incorporated the division's oversight role of environmental surveillance and monitoring. Additionally, several federal and state laws support this effort: (1) the federal Endangered Species Act of 1973 (ESA), as amended, provides for the inventory, listing, and protection of species in danger of becoming extinct and/or extirpated, and conservation of the habitats on which such species thrive, (2) the National Environmental Policy Act (NEPA), requires that federally-funded projects avoid or mitigate impacts to listed species, (3) the Tennessee Rare Plant Protection and Conservation Act of 1985 (Tennessee Code Annotated Title 11-26, Sects. 201-214), provides for a biodiversity inventory and establishes the State list of endangered, threatened, and special concern taxa, (4) National Resource Damage Assessments (NRDA) as directed by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by SARA (Superfund Amendments and Reauthorization Act of 1986), relating to damages to natural resources on the ORR.

Methods and Materials

Field mapping of native and exotic invasive plant species were completed by utilizing grid pattern transects and traverses where 15 meter diameter mini-plots were documented on 200 meter centers. Exotic and rare plants were mapped and documented if found between mini-plot intervals.

Geomorphic habitats such as small drainage ravines, floodplains, wetlands, watersheds, cedar barrens, rock outcroppings, cliffs, and karst features (springs, caves, sinkholes) were surveyed for rare plant taxa.

Each field station (mini-plot) was mapped and located using a Global Positioning System (GPS) hand-held field unit (Garmin™). Each field station was defined as a 50-foot circle from center point or circumference. Plant taxa were organized and compartmentalized as: canopy, subcanopy, shrub, herbaceous, and groundcover layers. Digital camera images of plants were made to document sensitive communities and rare species. Additionally, the boundaries of the pine deadfall areas (pine-beetle devastated areas) were mapped whenever possible in the field. These sites may become important ecological study areas to determine if native climax species or exotic pest plant invasions will re-establish in these areas.

Terrestrial plant species were collected for preservation and documentation as herbarium specimens. Plants collected were either in flower or fruit, were pressed and dried, and mounted on herbarium paper with appropriate identification labels. Herbarium specimens are a useful tool for the documentation and confirmation of plant species (especially rare species) encountered in the field. Care was taken while collecting plant specimens so as not to destroy or damage a rare plant colony.

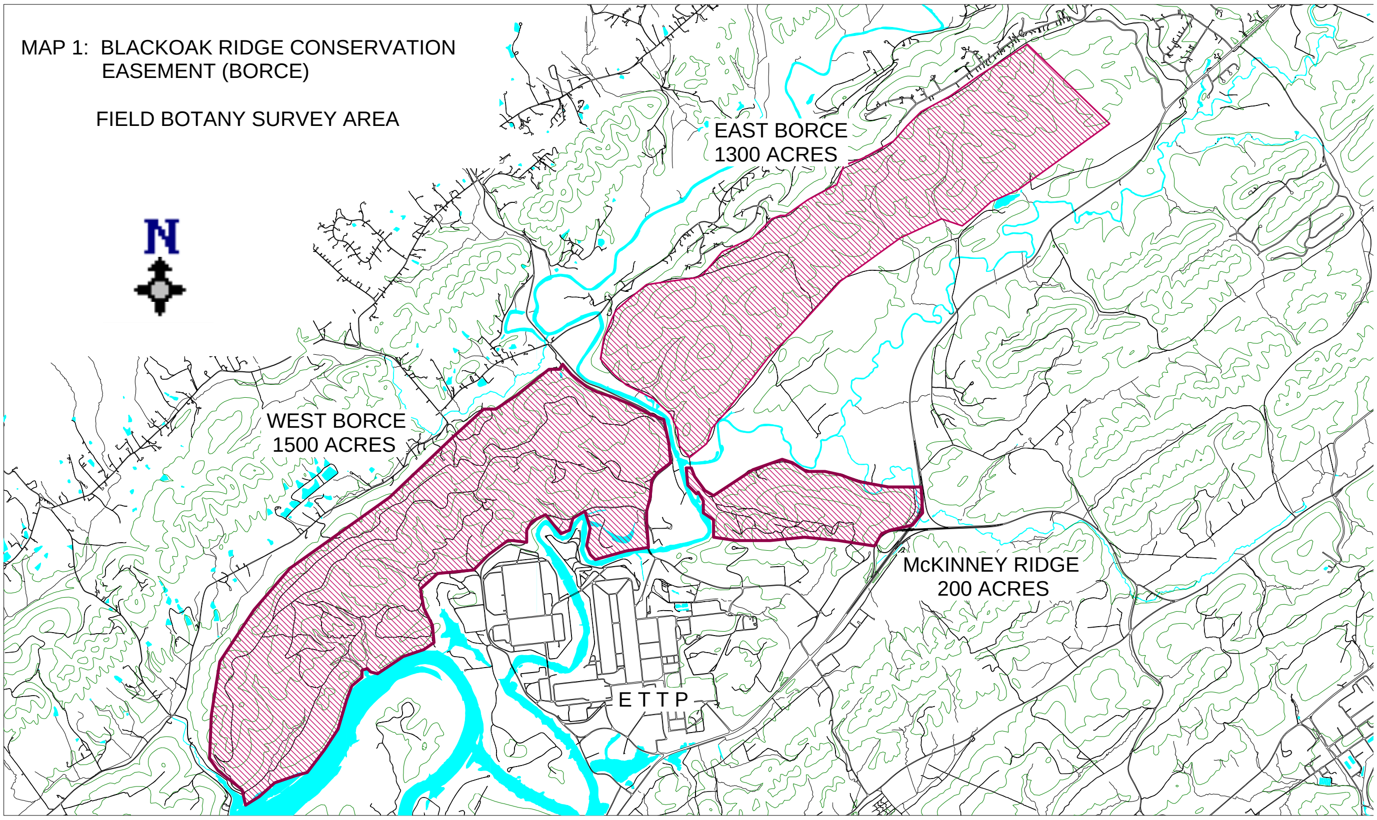
Field data sheets (survey logs) were recorded for each survey station and later placed in a database for inclusion in the environmental monitoring report. Field monitoring methods and health and safety procedures will follow the guidelines in the division's "Standard Operating Procedures" and "Health, Safety, and Security Plan."

Results and Discussion

Vascular plant field surveys continued on portions of the ORR during 2005; particularly wetlands, the new Environmental Management Waste Management Facility (EMWMF) haul road, and the BORCE. Additionally, rare plant colonies were identified and mapped on the ORR vicinity as follows: (1) Blackoak Ridge north of the Horizon Center, (2) Blackoak Ridge near Key Springs Road, (3) Union Valley Road near the Rogers Quarry operations, (4) University of Tennessee Arboretum, and (5) Oak Ridge National Laboratory near the Robotics and Process Systems Complex. Some of these sites had been previously observed by DOE contractors, but not documented with the TDEC DNH. Division staff recorded these findings and submitted rare plant forms to the TDEC DNH. Flora documented included colonies of pink lady slippers (*Cypripedium acaule* Ait.), goldenseal (*Hydrastis canadensis* L.), and ginseng (*Panax quinquefolius* L.) plants. Plants collected from the field were pressed and herbarium specimens prepared, and are stored in the division laboratory. Several colonies of pest plant invasions (i.e., kudzu) were located on portions of the western BORCE. Division staff also provided botanical oversight by participating in several ecological field site walkovers of proposed areas scheduled for remedial action cleanup projects at East Tennessee Technology Park.

Conclusions

Fieldwork remains to be completed on portions of the BORCE, particularly to map additional areas of exotic pest plant invasions. The division will continue to report new rare plant findings to the TDEC DNH and provide field support as needed. Specific rare plant locations are available upon request from the TDEC DNH in Nashville (http://www.tennessee.gov/environment/nh/).



Map 1: Field Botany Survey Area

References

Awl, D.J. June 1996. *Survey of Protected Vascular Plants on the Oak Ridge Reservation, Oak Ridge, Tennessee*. ORNL-Environmental Restoration Division. Lockheed Martin Energy Systems. ES/ER/TM-194.

Drake, Sara J., et al. March 2003. *Assessment of Non-Native Invasive Plant Species on the U.S. DOE Oak Ridge National Environmental Research Park.* Castanea 68:15-30.

Gleason, H.A. & Cronquist, A. 1991. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada.* The New York Botanical Garden, Bronx, New York.

Radford, A.E., et al. 1968. *Manual of the Vascular Flora of the Carolinas*. The University of North Carolina Press, Chapel Hill, N.C.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement: Agreement between the Department of Energy and the state of Tennessee*. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

Tennessee Exotic Pest Plant Council. April 2002. *Invasive Exotic Pest Plants in Tennessee*. Journal of the Tennessee Academy of Science 77:45-48.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

Wofford, B.E. and E.W. Chester. 2002. *Guide to the Trees, Shrubs, and Woody Vines of Tennessee*. The University of Tennessee Press. Knoxville, Tennessee.

CHAPTER 2: BIOLOGICAL/FISH AND WILDLIFE

Diatom Community Responses to Ecotoxicological Stressors in Oak Ridge Reservation Streams

Abstract

Communities of attached benthic algae (periphyton) contain diatom taxa with individual tolerance to anthropogenic stress (e.g., elevated metals concentrations), and provide a good analysis of shifts in community composition for identifying stressed water quality (Genter et al. 1988, Dixit et al. 1992, Kelly et al. 1995). Thus, water quality can be characterized by evaluating the results of qualitative and quantitative measurements of the algal community (Porter et al. 1993). The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division), Environmental Monitoring Section, reinstated monitoring of diatom communities in Oak Ridge Reservation (ORR) watersheds during 2005. Benthic algae was collected using artificial substrates on a monthly rotation for seven months (May-December) in Bear Creek, East Fork Poplar Creek, Melton Branch, White Oak Creek, and four reference streams to test the water quality and ecological recovery of these aquatic systems impacted by upstream Department of Energy (DOE) operations. Data collection and measurements of stream parameters included: (1) preparation of a comprehensive flora of diatom genera and species (Bacillariophyceae), and non-diatom taxa (e.g., Cyanophyta) comprising the periphyton communities on the ORR, (2) investigation of shifts in the periphyton community composition and succession (pioneer and climax taxa) utilizing diatom counting data, (3) determination of the total number of all algal genera and families within the periphyton community, (4) examination of downstream variation in diatom community structure to distance from headwater impacts, and (5) collection of field data including water quality (e.g., pH, conductivity), stream velocity, and photosynthetic light data. Results from ten periphyton monitoring sites were compared to their respective reference streams (four) located in the same watershed or geomorphological province as the associated test sites. Diatoms and non-diatom taxa were keyed-out to the generic level (including some identifications to the species level). Results of the 2005 monitoring suggest a general trend of increasing diatom diversity with distance from the DOE source of contamination. The results for the White Oak Creek and Melton Branch sites, which currently are undergoing massive environmental cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), remain unclear at this time.

Introduction

Periphyton is a basal food web assemblage of algae and other microorganisms (fungi, bacteria, detritus, microbes, protozoa, diatoms, green algae, macroinvertebrates, and blue-green algae) that colonize benthic substrates in aquatic systems (Stoermer and Smol 1999, Stevenson et al. 2001). Diatoms, a major component of periphyton, are unicellular microscopic “plants” (actually photosynthetic protists with chloroplasts) that are members of the algal class Bacillariophyceae. Unlike soft-bodied filamentous algae, diatoms have two overlapping parts made of opaline silica (known as frustules or valves) that fit together like the lid on a petri dish. Taxonomic classifications of diatom species are keyed on the diagnostic ornamented morphology, size and shape of respective diatom valves.

Diatoms have been used for decades as indicators of water quality impairment (Kolkwitz and Marssom 1908, Patrick 1973, Stevenson and Lowe 1986, Round 1991). Shifts in genera composition and abundance of diatoms and other freshwater algae can be used to infer anthropogenic stress in aquatic systems (Stevenson et al. 2002). Anthropogenic stressors can induce biotic perturbations to aquatic ecosystem food webs resulting in ecological changes or shifts to periphyton, macroinvertebrate, submersed macrophyte, and fish populations (Vitousek et al. 1997, EPA 1998, Barbour et al. 1999, Smith et al. 1999, Fore and Grafe 2002). Therefore, incorporating a diatom-monitoring task with other sensitive aquatic bio-indicators (i.e., macroinvertebrates) provides an additional set of bio-criteria to the assessment of the ecological integrity of a stream.

The health of aquatic ecosystems can be compromised by a variety of anthropogenic stressors such as heavy industry and associated land-clearing activities (Adams 2001). Benthic communities that have colonized aquatic habitats will exhibit responses to environmental stress manifested through sentinel organisms exposed to pollution. Since the upper reaches of Bear Creek and East Fork Poplar Creek originate within the pollution source areas of the Y-12 National Security Complex (DOE), then division staff expected to observe a more diverse periphytic diatom community with distance downstream from the source of contamination. Staff also expected to observe bio-diverse diatom community conditions in reference streams when compared to impaired streams. Finally, the division expected to observe deformed diatom frustules in ORR streams contaminated with heavy metals (zinc, cadmium, mercury, lead). McFarland et al. (1997), Ruggiu et al. (1998), and Gold et al. (2003) observed abnormalities in *Fragilaria sp*. morphology in periphyton samples collected from streams impacted by high metals concentrations. Environmental stressors to ORR aquatic systems include heavy metals, nutrients, chemicals, and radionuclides.

Many factors validate the rationale for using diatoms in water quality monitoring. Benthic algal communities, especially diatoms, have a rapid response and recovery time to a wide range of pollutants because of their relatively short life cycle (as compared to fish or macroinvertebrates), and their ability to quickly re-colonize formerly disturbed or impacted sites (Stevenson et al. 2001). Diatoms exist within narrow environmental conditions (light, temperature, pH, turbidity, water chemistry), and are thus excellent indicators of different levels and causes of anthropogenic stress due to industrial pollution and high nutrient loads (Dixit et al. 1992, Bahls 1993). Because of their varying sensitivities to environmental stressors, diatoms allow a measurement of the rate of change in water quality (Dixit et al., 1992). Species inhabiting headwater streams may be more susceptible to anthropogenic disturbance than species adapted to the fluctuating conditions in mid-order streams (Ward and Stanford 1983). Water chemistry variations (due to anthropogenic stress) and other physiochemical factors significantly influence ecological succession in benthic communities along a longitudinal gradient at upstream and downstream sites (Vannote et al. 1980, Medley and Clements 1998). These factors may produce later successional communities at downstream sites (Medley and Clements 1998).

In 2005, division staff conducted field and laboratory activities as part of the renewed diatom bio-monitoring project. The goal of this project was to enhance previous diatom taxonomic baseline information (1998-2000 data) in order to assess the water quality of streams within the ORR that have received and continue to receive industrial pollutants from DOE operations. Artificial substrates were deployed in ORR streams to allow diatom colonization for a predetermined period of time (May-December 2005). Samples were collected, preserved, and examined to determine the percentage of algal taxa present in test and reference sites. By examining diatom community assemblages and identifying shifts in taxa composition and structure over time, inferences regarding stream conditions can be determined. Completed objectives include: (1) collected seven sets (May-December 2005) of periphyton samples and related field monitoring data, (2) prepared comprehensive taxonomic lists and supporting digital camera microscopic images (Kodak® EasyShare DX3700) of diatom and non-diatom taxa identified from periphyton assemblages that had continuously colonized artificial substrates for seven months, (3) diatom community compositional data were collected for the evaluation of creek recovery to distance from upstream sources of industrial contamination, and (4) examined the adaptation of diatom communities to response variables (heavy metals, nutrients, flood spates, pH, temperature, conductivity, dissolved oxygen, stream velocity, tree canopy shading). Sampling began after substrates had been deployed for one month, and thereafter, samples were collected on a monthly basis to examine hypothesized shifts in diatom community composition over time. A concurrent division project monitors the benthic macroinvertebrate community to evaluate water quality and the recovery status of ORR streams.

Materials and Methods

Four streams were examined in 2005 to assess potential water quality impacts from DOE related activities on the ORR. Locations in East Fork Poplar Creek, Bear Creek, White Oak Creek, and Melton Branch were sampled to test for periphyton (diatoms) community composition and analysis. Associated reference sites included Brushy Fork Creek, Hinds Creek, Mill Branch, and a White Oak Creek headwater site. These are 2^{nd} to 3^{rd} order streams, and riparian canopy cover ranges from dense, heavily shaded locations to open canopy (no shade). The locations of all 14 test and reference sites are shown on Maps 1and 2. Below is a list of the sampling sites in stream kilometers (miles).

East Fork Poplar Creek: EFK 23.4 (14.5), EFK 13.8 (8.6), and EFK 6.3 (3.9). Reference site: Brushy Fork / BFK 7.6 (4.7), Hinds Creek / HCK 20.6 (12.8)
Bear Creek: BCK 12.3 (7.6), BCK 9.6 (5.9), BCK 4.55 (2.8), BCK 0.63 (0.4). Reference site: Mill Branch / MBK 1.6 (1.0)
White Oak Creek: WCK 3.9 (2.4), WCK 2.3 (1.4), and Melton Branch / MEK 0.3 (0.2). Reference site: WCK 6.8 (4.2)

Field methods and protocols employed during this project included the U.S. EPA "Periphyton Sampling Protocol" (Barbour et al. 1999), and the USGS "Methods for Collecting Algal Samples as Part of the National Water Quality Assessment Program" (Porter et al. 1993).

Division personnel deployed artificial substrates to provide a consistent medium of replicating the periphyton community present at each monitoring location. Artificial substrates can reduce the heterogeneity (patchiness) of algae affixed to natural substrates and can be used to compare water quality among streams with disparate periphyton microhabitats (Porter et al. 1993, Stevenson and Pan 1999).

The artificial substrates were prepared by mounting twenty-four 5.76 cm^2 unglazed ceramic tiles on a standard red brick using silicon glue. The tiles provided a surface for diatom colonization. Three replicates were deployed (spaced about 60 cm apart) at each site to ensure retrieval of representative samples of the respective diatom communities, and as a hedge against substrate loss due to flash-flood events. The position of each brick was maintained against the current and high water by securing it with a rebar stake (30 cm) driven about 25 cm into the natural substrata. The artificial substrates were all deployed by May 15, 2005, and an in-stream incubation period of four weeks was allowed prior to initial sample collections. Artificial substrates were submerged approximately 15-45 cm deep along riffle zones wherever possible. During each field-sampling event, two tiles were randomly removed from each of the three brick replicates, placed in a labeled sample container, and packed in an ice cooler prior to leaving the site. The artificial substrates are then returned to their respective in-stream positions allowing the periphyton assemblage to continue development of a climax community on the remaining tiles. Field water quality parameters were taken at each artificial substrate location using a Horiba® U-10 Water Quality Checker (pH, temp, conductivity, dissolved oxygen, and turbidity), photosynthetic light readings were recorded with a Li-Cor® quantum sensor, and stream velocity was measured with a Global® Flow Probe. Field data were recorded in a logbook at each monitoring station. Site photographs and global positioning system (GPS) readings were obtained for each field monitoring station.

On return to the laboratory, field samples were preserved with Lugol's solution, and stored in the refrigerator until further processing. Sample preparation consisted of dislodging the attached algae from the tiles by brushing with a new toothbrush, then rinsing the dislodged algae with deionized water, and collecting the resultant algal slurry in a small laboratory pan. Approximately 25 ml of slurry was transferred into a labeled plastic vial with a screw-cap lid for storage until taxonomic processing. The initial slurry volume of each sample was carefully measured in a laboratory-graduated cylinder and recorded in the logbook. Identification labels with site specific information was attached to each sample container. Duplicate samples were collected at 10% of the sites for quality assurance/quality control (QA/QC) purposes.

Water quality samples were collected in August 2005 in support of the periphyton sampling and monitoring. Water quality parameters: (1) metals (As, Cd, Ca, Cr, Co, Fe, Hg, Pb, Mg, Mn, Ni, K, Se, Na, Tl, Zn), (2) alkalinity, total, as CaCO3, (3) pH, conductivity, (4) ammonia, NO3 & NO2 nitrogen, total Kjeldahl nitrogen, total phosphate, (5) radiological (gross alpha, gross beta, gamma radionuclides), and (6) dissolved residue, suspended residue, COD, total hardness.

Algal slurry samples were examined by division staff using the Olympus® BH-1 stereo microscope and the Zeiss® inverted microscope (on loan from Oak Ridge National Laboratory Environmental Sciences Division). Laboratory analysis included taxonomic identification and enumeration of diatom species for each sampling site. Fresh and digested diatom material was prepared (methods per Bahls 1993, Barbour et al. 1999), and taxonomically identified using Smith 1950, Patrick and Reimer (1966, 1975), Prescott (1978), and Wehr and Sheath 2003. Enumeration of diatoms was completed on at least 10 fields-of-view or until 500 diatom valves were counted per sample at 400-power magnification. Diatom identifications were made to the genus level, and often species were determined. Several researchers have proposed the diatom genus as the appropriate taxonomic level for water quality assessment (Coste et al. 1991, Prygiel and Coste 1993, Kelly et al. 1995, Hill et al. 2000). Digital microscopic photographic images of many diatom identifications were archived on CD-ROM for future reference and taxonomic verification. The data and information generated by this project will be used to meet the objectives as defined in the introduction and to form a database for calculating the metrics.

Results and Discussion:

Field measurements including stream water temperature, pH, conductivity, turbidity, dissolved oxygen, flow, and light data were averaged to arrive at means for the entire exposure period of seven months. Field data results, laboratory sample analysis results, and diatom enumeration bench sheets, and metrics applications are available upon request at the TDEC DOE-O office. The laboratory analytical data from stream water quality samples are within normal ranges for surface waters in the ORR area.

For metric analysis, staff have adopted (and modified) a portion of the Kentucky Division of Water Diatom Bioassessment Index (DBI) (Brumley et al. 2004). The DBI is a multi-metric index that uses several diatom community structure metrics. It is intrinsically designed to be sensitive to nutrient enrichment, as well as other environmental insults including sedimentation salinity, acidity, and metals. Division staff have selected the following metrics for diatom data evaluation:

Total Number of Diatom Genera (TNDG): Total number of genera identified (those counted & those showing up on the scan of the slide), and is an estimate of diatom taxa richness; as water pollution increases, TNDG is expected to decrease, % Navicula, Nitzschia, Surirella (NNS): The sum of the relative abundances of all Navicula, Nitzschia, and Surirella taxa reflects the degree of siltation at a reach; these genera are motile and their abundance expresses the frequency and severity of sedimentation. In general, healthy streams should exhibit low NNS siltation results (percentages).

Total Number of Divisions (or Families) Represented (TDiv or TFam): A large number of algal divisions (or families) are consistent with good water quality. Taxonomic Data and Metrics Analysis: Table 1 is a classification of benthic algae (diatoms and non-diatom algae) found in ORR streams. All of these taxa have been identified in samples collected during 2005. Algae were taxonomically keyed using Smith 1950, Patrick and Reimer (1966, 1975), Prescott (1978), and Wehr and Sheath 2003. Pie charts 1-14 represent the total number of algal families represented at each monitoring and reference station. These charts provide the TFam for each reference and test site. Mill Branch reference site, MEK 0.3, and EFK 13.8 had the highest number of families represented (TFam), and the results suggest better water quality at these sites. Twenty-six algal genera (TNDG) were recorded for the Mill Branch reference site although dominated by Epithemiaceae. A photographic archive has been developed and saved on a CD-ROM to document taxa identifications, and are available for review on request at the division’s office in Oak Ridge.

Bear Creek:

The upper reaches of Bear Creek can be characterized as being nutrient enriched with relatively elevated gross alpha and gross beta activity compared to reference streams. Much of the flux of nitrates and radionuclides in upper Bear Creek has been attributed to S-3 Pond groundwater exchange with surface water along the geologic strike of the Maynardville Limestone (Knox Aquifer) underlying the creek (AJA Technical Services, Inc. 1999). Prior to closure, the S-3 Pond site received liquid nitric and uranium-based wastes for 35 years from Y-12 Plant processing facilities (HSW Environmental Consultants, Inc. 1994). Waste disposal sites (e.g., Bear Creek Burial Grounds) in west Bear Creek Valley contribute additional contaminants to surface water and groundwater including uranium, cadmium, and technetium-99 (UT-Battelle, LLC 2002). Surface water analytical data reflected high concentrations of nitrates. BCK 12.3 radiological data reported 214 picoCuries per Liter (pCi/L) gross alpha and 287 pCi/L gross beta while the downstream BCK 4.55 site had results of 15.8 pCi/L gross alpha and 10.8 pCi/L gross beta. In contrast, the Brushy Fork reference site had sample data values of -0.8 pCi/L gross alpha and 2.7 pCi/L gross beta. The response of diatoms to radionuclide contamination and their uptake capacity in Bear Creek periphyton communities is unclear. Studies have shown that cesium-137 introduced into a watershed becomes attached or bound to clay particles (Alberts et al. 1979). Clay-bound cesium-137 suspended in aquatic systems may become trapped and enmeshed with benthic algal communities downstream (Sansone et al. 2002). Research by Brown et al. (2003) determined that water column radionuclides are introduced to diatom communities via direct uptake (enzymatic action), or from trapped contaminated-clay particles in the algal mat.

Diatom response to metals pollution includes modification of their frustule structure and morphology (Deniseger et al. 1986, Ruggiu et al. 1998, Gold et al. 2003). Staff observed several deformed diatom cells (Fragilaria sp. and Synedra sp.) in samples from BCK 12.3 and BCK 9.6 suggesting water quality impairment. Diatom morphological abnormalities may be a symptom of stress, and could be a useful tool to monitor the health of an aquatic ecosystem (Ruggiu et al. 1998). Also, the BCK 12.3 site occasionally developed massive macroalgal blooms. This suggests nutrient loading from upstream DOE wastewater treatment operations (Y-12 West End Treatment Facility).

Chart 15 illustrates the response of the Bear Creek diatom community to distance from upstream DOE contamination sources. The chart lists three sets of enumerated data for each Bear Creek monitoring station (BCK 12.3, BCK 9.6, BCK 4.55, and BCK 0.63) plus the Brushy Fork reference site. The artificial substrates were deployed in May 2005. The first diatom sample sets were collected in June, and thereafter samples were retrieved once a month. Only June, September, and November 2005 data have been counted and plotted. The chart plots percent pollution tolerant diatoms, percent pollution sensitive diatoms, and percent non-diatom algae. Analysis of chart 15 reveals a general trend where pollution tolerant diatoms dominate the community at the impaired BCK 12.3 site, and pollution sensitive diatoms increase downstream and at the reference site. Diatom taxa ranked as pollution tolerant or pollution sensitive was adopted from the taxonomic list developed by Lange-Bertalot (1979).

The TNDG metric is an estimate of algal taxa (genera) richness. As water pollution increases, the TNDG should decrease. In general, a more pristine stream has greater taxa richness. The Bear Creek TNDG metric results showed a slight increase to distance downstream from the DOE contamination source. The BCK 12.3 site scored 24 algal genera and BCK 4.55 (downstream) scored 26 algal genera representatives. This trend represents a slight improvement in water quality downstream.

The TFam metric is an estimate of the total number of algal families represented in a sample. A large number of algal families observed in a periphyton community represent good water quality. The Bear Creek TFam results were inconclusive because BCK 12.3, BCK 9.6, BCK 4.55, BCK 0.63, and the Brushy Fork reference site produced the same number of algal families. However, BCK 12.3, BCK 9.6, BCK 4.55, and BCK 0.63 each scored 8 families and the Mill Branch reference site scored 11 families. This metric trend suggests water quality impairment in Bear Creek compared to the Mill Branch reference site.

The siltation metric (NNS) analysis of BCK 12.3 was determined to be 62 percent, the highest for all ORR diatom-monitoring sites. In contrast, the Brushy Fork reference NNS metric was determined to be 28 percent. Healthy streams should have low siltation metric results. The NNS metric evaluation suggests water quality impairment at the BCK 12.3 site.

Periphyton sample material collected in November from the Mill Branch reference site was dominated by Rhopalodia sp. and Epithemia sp. (Epithemiaceae). These taxa are considered to be superior competitors and nitrogen-fixers because they harbor endosymbiotic cyanobacteria (Mayer and Galatowitsch 2001, Scott et al. 2005). Rhopalodia sp. and Epithemia sp. respond when nitrogen is low in streams, and their presence is considered an indicator of a nitrogen deficient habitat (Lowe et al. 1984, Stevenson and Pan 1999). The response variable influencing Mill Branch nitrogen levels is unknown at this time.

East Fork Poplar Creek:
The upper reaches of East Fork Poplar Creek (EFPC) have historically high concentrations of mercury, cadmium, chromium, copper, nickel and zinc discharged from DOE operations (Hinzman 1998). Laboratory analytical data from surface water samples collected during 2005 indicated small detections of zinc, mercury, nickel, and copper at EFK 23.4. Diatom response to metals pollution includes modification of their frustule structure and morphology (Deniseger et al. 1986, Ruggiu et al. 1998, Gold et al. 2003). Interestingly, staff observed a few deformed Nitzschia sp. and Fragillaria sp. frustules in samples from EFK 23.4 and EFK 13.8 suggesting water quality impairment. Diatom morphological abnormalities are a symptom of stress, and could be a useful tool to monitor the health of an aquatic ecosystem (Ruggiu et al. 1998).

Chart 16 illustrates the response of the EFPC diatom community to distance from upstream DOE contamination sources. The 2005 EFPC diatom community pollution tolerant/pollution sensitive diatom trends are similar between EFK 23.4 and the Hinds Creek reference site. Otherwise, it is difficult to draw a conclusion about this chart except there is a large population of non-diatom algae at EFK 13.8, and the pollution sensitive diatom population seems to out-compete the pollution tolerant species at EFK 6.3. A downstream trend toward increasing species richness appears to be exhibited between EFK 23.4 and EFK 6.3.

The TNDG metric is an estimate of algal taxa (genera) richness. As water pollution increases, the TNDG should decrease. In general, a more pristine stream has greater taxa richness. The East Fork Poplar Creek TNDG metric results showed a slight increase to distance downstream from the DOE contamination source. The EFK 23.4 site scored 19 algal genera, EFK 6.3 site (downstream) scored 22 algal genera, and the Hinds Creek reference site scored 24 genera. This trend represents a slight improvement in East Fork Poplar Creek water quality downstream, and shows a slight impairment of the creek when compared to the Hinds Creek reference site TNDG results.

The TFam metric is an estimate of the total number of algal families represented in a sample. A large number of algal families observed in a periphyton community represent good water quality. The East Fork Poplar Creek TFam results indicate a slight increase in scores between EFK 23.4 (8 families) and EFK 13.8 (9 families), but the score for EFK 6.3 drops to 6 families. The Hinds Creek reference site produced a TFam score of 7 families and the Mill Branch reference site produced a result of 11 families. These results suggest a slight water quality improvement in East Fork Poplar Creek downstream, then a reversal in quality. This variation could be due to the high stream velocity (scouring) at EFK 6.3 and grazing by fish and snails. East Fork Poplar Creek TFam results indicate water quality impairment when compared to the Mill Branch reference site results.

The siltation metric (NNS) analysis of EFK 23.4 was determined to be 41 percent. In contrast, the siltation index of the downstream EFK 6.3 and the Hinds Creek reference site was determined to be 23 percent and 33 percent respectively. Healthy streams should have lower siltation metric results. The NNS metric evaluation suggests slight impairment at the EFK 23.4 monitoring site.

White Oak Creek/Melton Branch:
Periphyton samples collected from the White Oak headwaters (WCK 6.8 reference) exhibited very low biomass, and enumerating the samples required counting a large number of microscope fields-of-view (60-100). This could be due to high stream velocity and the large snail population that may graze the algae. Low algal biomass at WCK 3.9 may also be a result of periphyton grazing by snails. Biomass was higher at WCK 2.3 and significantly higher at MEK 0.3 (perhaps nutrients from the CERCLA reclamation and re-seeding in Melton Valley). Staff generally observed a reverse trend in species richness because the biomass was so low at the upstream reference site (WCK 6.8). However, in contrast to Bear Creek and East Fork Poplar Creek, the main source of contamination is downstream of the headwaters in this case (except for some nutrients and siltation from the Spallation Neutron Source site on Chestnut Ridge). Staff also observed a large percentage (38%) of non-diatom algae (Stigeoclonium, Colonial Greens) at the MEK 0.3 site. The green algae colonization suggests nutrient enrichment. Chart 17 reflects these observations.

The diatom population at WCK 2.3 and WCK 3.9 was dominated by Cocconeis sp. and Achnanthes sp. (40-60 %). Cocconeis placentula is a diatom that tolerates organic pollution, and this high biomass in Melton Valley suggests nutrient loading from surface runoff, reclamation activities and plant discharges. Achnanthes minutissima is a diatom widely recognized as being tolerant to metals and organic pollution, and a species used as a yardstick of stream recovery (Lange-Bertalot 1979, Deniseger et al. 1986, Kelly et al. 1995, Medley and Clements 1998). White Oak Creek and Melton Branch diatom sample examination results for A. minutissima populations seem to contradict these hypothesized trends, and therefore the diagnosis remains unclear. Gold et al. (2002) hypothesized that A. minutissima is able to develop a good resistance to metal pollution, but can be impaired by other physical and chemical parameters independently of metal concentrations in the water column.

Water quality samples were collected from MEK 0.3 and the resultant analyses indicated gross beta activity of 390 pCi/L, but reference site data was not available at this time. Periphyton samples collected from White Oak Lake in a 1967 study included the principal pioneer-colonizing algae Microcystis sp., and Oscillatoria sp. (Cyanophyta), and Navicula sp., Cymbella sp., and Fragilaria sp. (Bacillariophyceae) (Neal et al. 1967). Later-successional taxa included Oedogonium sp., Spirogyra sp., and Stigeoclonium sp. (Chlorophyta). Microcystis sp. and Oscillatoria sp. responded with increased biomass to organic pollution in White Oak Lake whereas the diatoms had responded to the metals contamination (including cobalt-60 and cesium-137). Staff observed very similar suites of pioneer and later-successional algae colonizing benthic habitats subjected to high nutrient load and stream disturbances (i.e., flood events).

The TNDG metric is an estimate of algal taxa (genera) richness. As water pollution increases, the TNDG should decrease. In general, a more pristine stream has greater taxa richness. The White Oak Creek and Melton Branch TNDG results indicate WCK 3.9 had the highest taxa richness with 26 genera. WCK 6.8 reference site had the lowest number of genera (20) for all sites. White Oak Creek exhibited a general trend of decreasing taxa richness downstream of WCK 3.9.

The TFam metric is an estimate of the total number of algal families represented in a sample. A large number of algal families observed in a periphyton community represent good water quality. The TFam results for White Oak Creek and Melton Branch are inconclusive because the same number of families were observed at all sites.

The NNS (siltation) metric analysis of WCK 6.8, WCK 3.9, WCK 2.3, and MEK 0.3 yielded results of 12-16 percent siltation results. Low NNS siltation (percent) is indicative of good water quality.

Conclusions:

Diatom communities in ORR streams are generally stressed compared to reference streams. Signs of impairment include distorted diatom frustules, algal blooms, and siltation. The Mill Branch reference site shows signs of impairment due to domination by nitrogen-fixing diatoms (Epithemiaceae). This suggests a nitrogen-poor habitat, but the source of this perturbation is unclear. Accordingly, the Mill Branch site may not be used in future diatom-monitoring activities. Diatom communities in East Fork Poplar Creek and Bear Creek generally exhibited trends of improved biodiversity with distance downstream from the headwater sources of DOE pollution. WCK 2.3 and WCK 3.9 exhibited an abundance of the diatom Cocconeis placentula that tolerates organic pollution. The high biomass of this diatom in Melton Valley suggests nutrient loading from surface runoff, reclamation activities and plant discharges. BCK 12.3 had the highest siltation index (NNS metric) of all ORR diatom-monitoring stations. Laboratory analysis of surface water samples from BCK 12.3 reported significant concentrations of radiological constituents (gross alpha and gross beta). Also, nuisance algal blooms are a seasonal occurrence at BCK 12.3 due to nutrients released from upstream DOE wastewater operations (West End Treatment Facility).

Based on the 2005 results, continued sampling and monitoring of diatoms on the ORR is warranted. These benthic communities are sensitive to environmental change, and the ORR is in a state of change due to numerous construction and environmental cleanup projects. It would be good to generate several years of diatom data to better understand the dynamics of the community structure in the ORR streams and the interaction with response variables. Continued monitoring and assessments of benthic diatom communities would define ORR stream recovery related to DOE remedial actions and cleanup projects in the Bear Creek, East Fork Poplar Creek, and Melton Valley watersheds. Future monitoring should include community trend analysis for specific diatoms such as Achnanthes minutissima to clarify 2005 data analysis discrepancies.

TABLE 1: TAXONOMIC CLASSIFICATION OF BENTHIC ALGAE FOUND ON THE ORR**

(**Prescott 1978)

PHYLUM CHRYSOPHYTA

SUB-PHYLUM BACILLARIOPHYCEAE

ORDER CENTRALES (DIATOMACEAE)

Family Coscinodiscaceae

Melosira varians

ORDER PENNALES (DIATOMACEAE)

Family Achnanthaceae (Achnanthales)

Achnanthes minutissima
Achnanthidium minutissimum
Cocconeis placentula
Rhoicosphenia curvata

Family Cymbellaceae

Amphora ovalis
Cymbella prostrata
Cymbella sp.
Cymbella tumida

Family Epithemiaceae

Epithemia sp.
Epithemia turgida
Rhopalodia sp.

Family Eunotiaceae

Eunotia sp.

Family Fragilariaceae

Diatoma vulgare
Fragilaria pulchella
Fragilaria sp.
Meridion circulare
Synedra sp.
Synedra ulna
Tabellaria sp.

Family Gomphonemaceae

Gomphonema acuminatum
Gomphonema angustatum
Gomphonema augur
Gomphonema olivaceum
Gomphonema parvulum
Gomphonema sp.

Family Naviculaceae

Amphipleura sp.
Diploneis elliptica
Frustulia rhomboids
Frustulia sp.
Gyrosigma sp.
Navicula lanceolata
Navicula radiosa
Navicula sp.
Pinnularia sp
Stauroneis sp.
.

Family Nitzschiaceae

Nitzschia acicularis
Nitzschia dissipata
Nitzschia filiformis
Nitzschia linearis
Nitzschia palea
Nitzschia sigmoidea
Nitzschia sp.

Family Surirellaceae

Cymatopleura elliptica
Cymatopleura solea
Surirella ovalis

SUB-PHYLUM CHRYSOPHYCEAE

ORDER OCHROMOMADALES

Family Dinobryaceae

Dinobryon sp.

Family Synuraceae

Synura sp.

SUB-PHYLLUM XANTHOPHYCEAE

ORDER TRIBONEMATALES

Family Tribonemataceae

Tribonema sp.

ORDER VAUCHERIALES

Family Vaucheriaceae

Vaucheria sp.

PHYLUM EUGLENOPHYTA

ORDER EUGLENALES

Family Euglenaceae

Euglena sp.
Phacus sp.
Trachelomonas sp.

PHYLUM PYRRHOPHYTA

ORDER DINOKONTAE

Family Gymnodiniaceae

Gymnodinium sp.

Family Peridiniaceae

Peridinium sp.

Family Ceratiaceae

Ceratium sp.

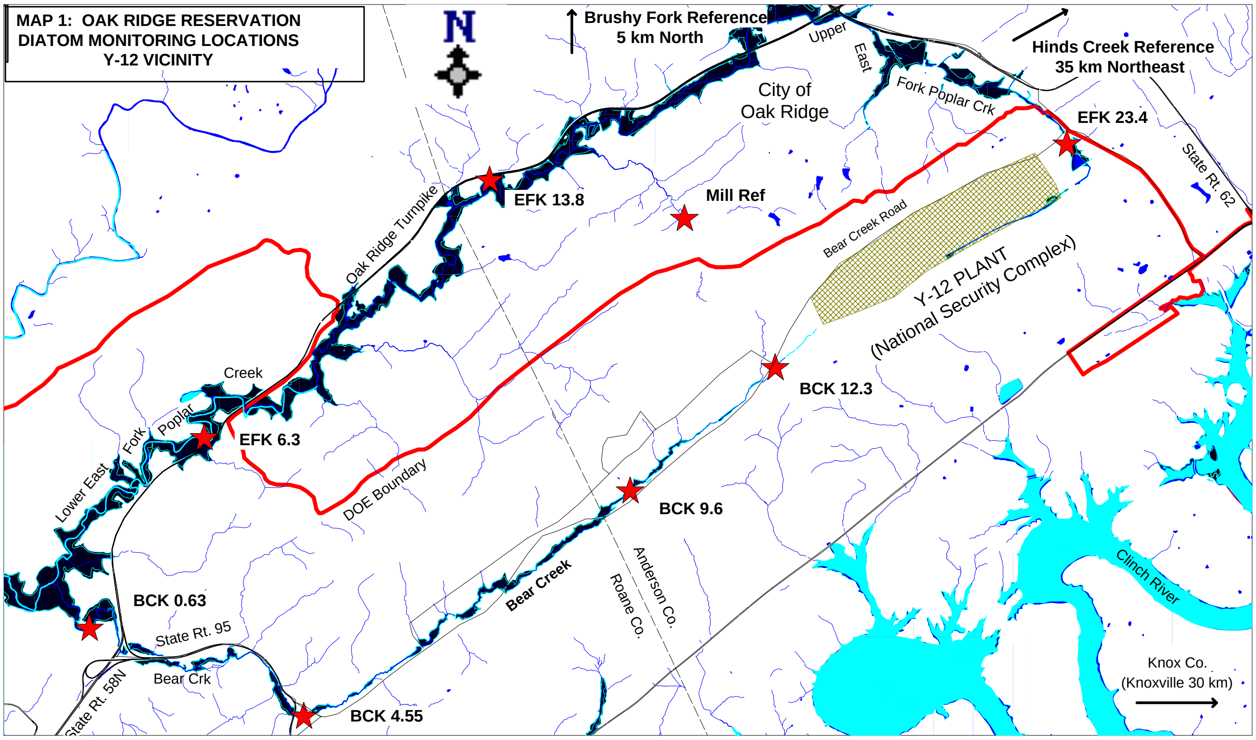
Table 1 Continued

PHYLUM CHLOROPHYTA
SUB-PHYLUM CHLOROPHYCEAE
ORDER CHAETOPHORALES
Family Chaetophoraceae
Chaetophora sp.
Draparnaldia sp.
Stigeoclonium sp.
Family Coleochaetaceae
Coleochaete sp.
ORDER CHLOROCOCCALES
Family Chlorococcaceae
Chlorococcum sp.
Planktosphaeria sp.
Tetraedron sp.
Family Oocystaceae
Ankistrodesmus sp.
Chlorella sp.
Dactylococcus sp.
Oocystis sp.
Family Scenedesmaceae
Scenedesmus sp.
Tetrastrum sp.
ORDER OEDOGONIALES
Family Oedogoniaceae
Bulbochaete sp.
Oedogonium sp.
ORDER SIPHONOCLADALES
Family Cladophoraceae
Basicladia sp.
Cladophora sp.
Rhizoclomium sp.
ORDER TETRASPORALES
Family Gloeocystaceae
Asterococcus sp.
Gloeocystis sp.
Family Tetrasporaceae
Tetraspora sp.
ORDER ULOTRICHALES
Family Ulotrichaceae
Ulothrix sp.

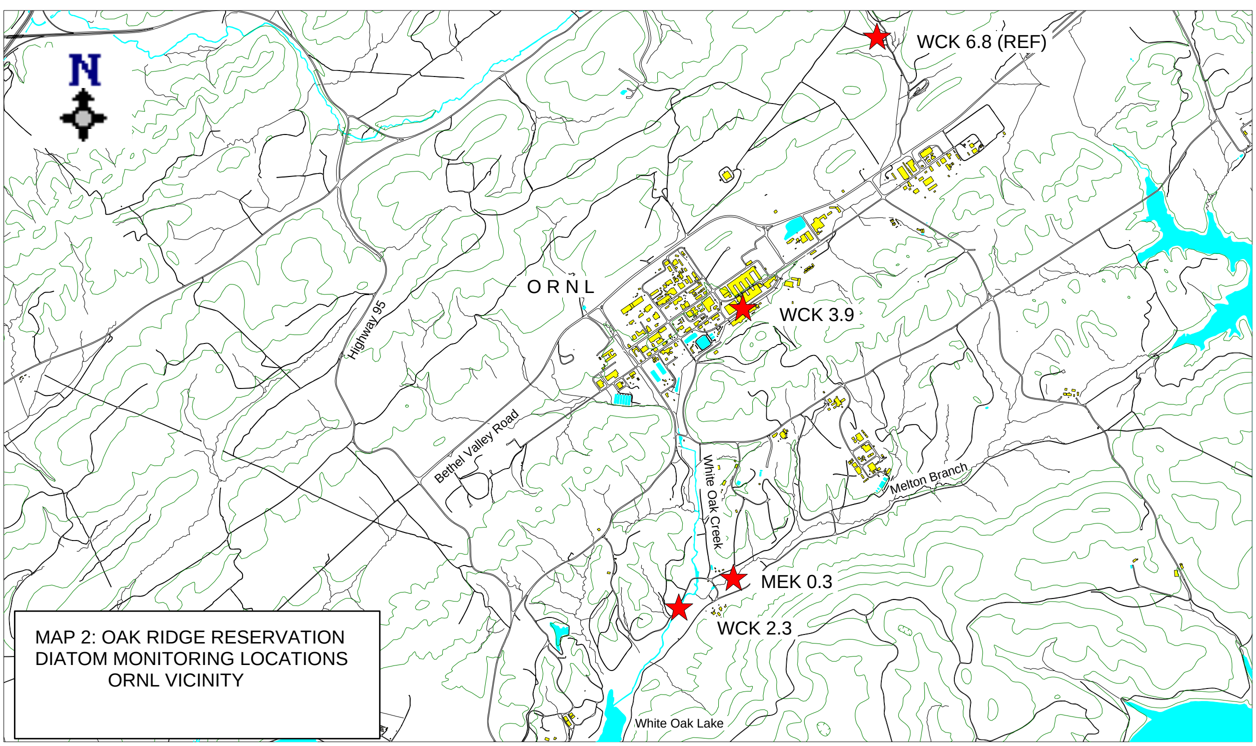
ORDER ZYGNEMATALES
Family Zygnemataceae
Mougeotia sp.
Sirogonium sp.
Spirogyra sp.
Zygnema sp.
Family Desmidiaceae
Closterium sp.
Cosmariium sp.
Desmidium sp.
Euastrum sp.
Micrasterias sp.
Penium sp.
Pleurotaenium sp.
Staurastrum sp.

PHYLUM CYANOPHYTA
ORDER CHROOCOCCALES
Family Chroococcaceae
Anacystis (Aphanocapsa) sp.
Aphanothece sp.
Chroococcus sp.
Gloeocapsa sp.
Merismopedia sp.
Microcystis sp.
Family Oscillatoriales
Lyngba sp.
Oscillatoria sp.
Phormidium sp.
Family Rivulariaceae
Gloeotrichia sp.
Rivularia sp.
Family Scytonemataceae
Scytonema sp.
Tolypothrix sp.

PHYLUM RHODOPHYTA
ORDER NEMALIONALES
Family Batrachospermaceae
Batrachospermum sp.



Map 1: Oak Ridge Reservation Diatom Monitoring Locations Y-12 Vicinity



Map 2: Oak Ridge Reservation Diatom Monitoring Locations ORNL Vicinity

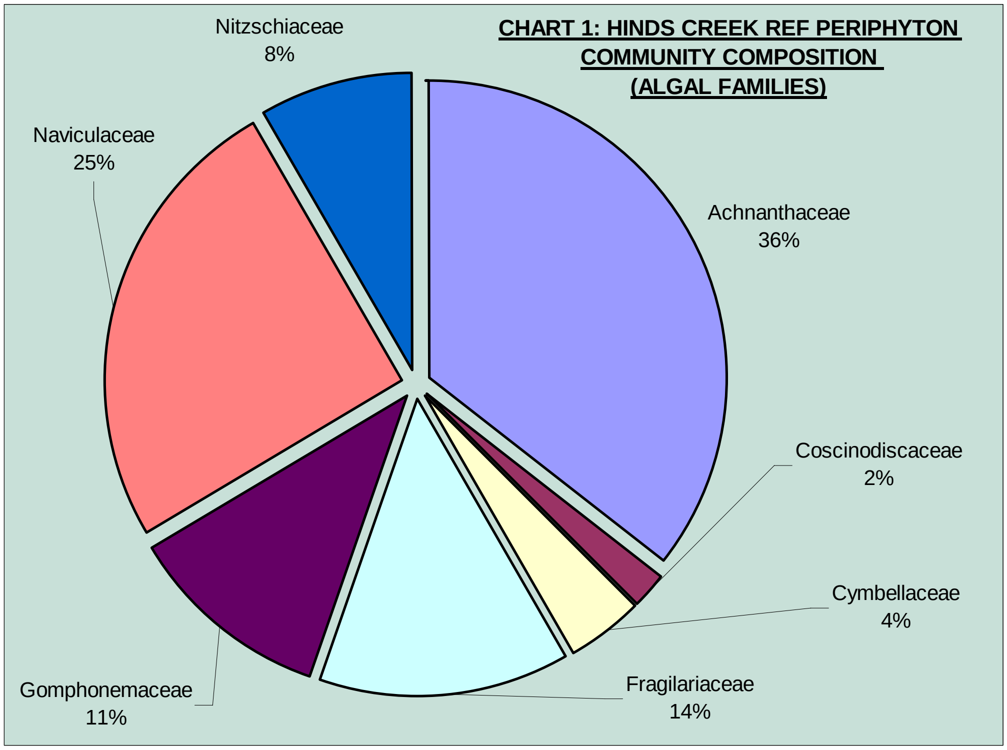


CHART 1: HINDS CREEK REF PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)
Nitzschiaceae 8%
Naviculaceae 25%
Achnanthaceae 36%
Coscinodiscaceae 2%
Cymbellaceae 4%
Fragilariaceae 14%
Gomphonemaceae 11%

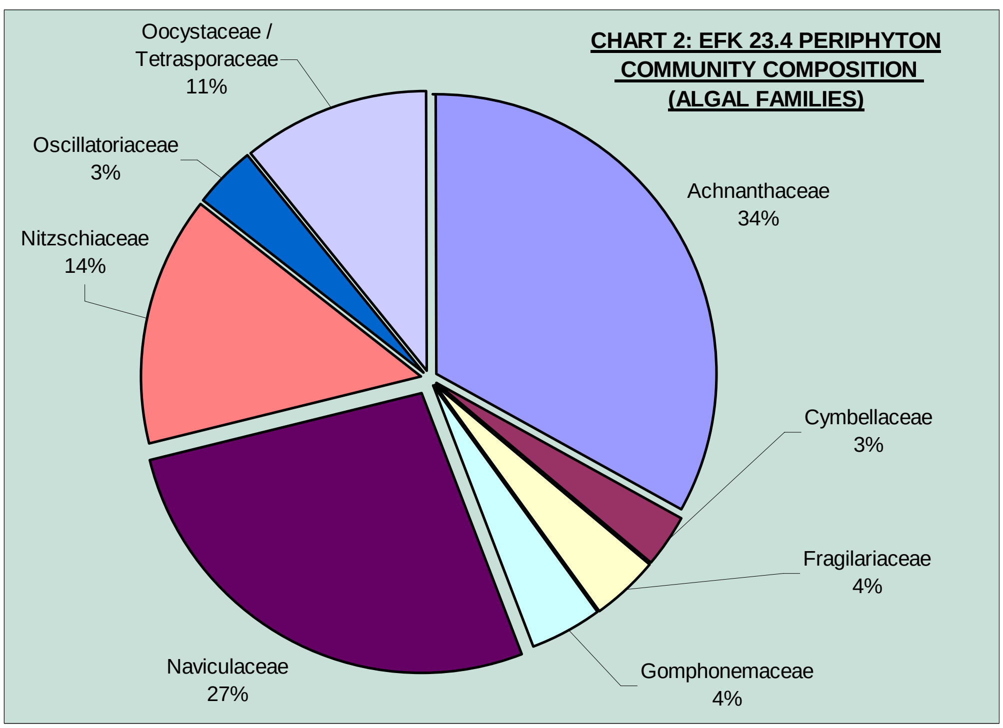


CHART 2: EFK 23.4 PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)
Oocystaceae / Tetrasporaceae 11%
Oscillatoriaceae 3%
Nitzschiaceae 14%
Achnanthaceae 34%
Cymbellaceae 3%
Fragilariaceae 4%
Gomphonemaceae 4%
Naviculaceae 27%

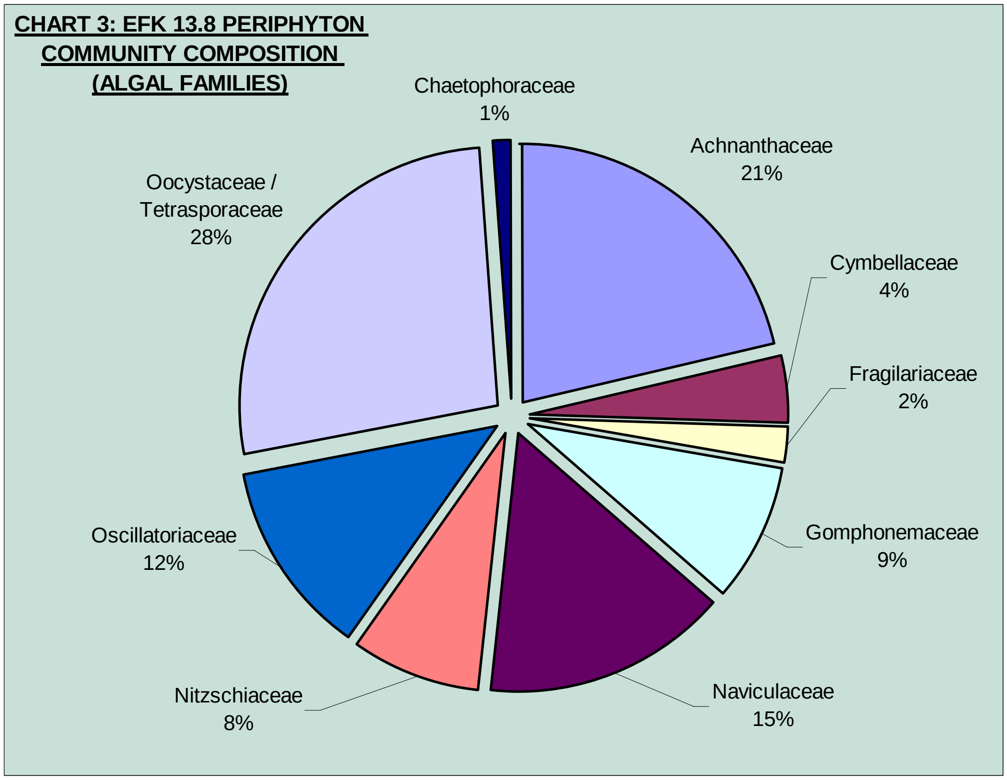


CHART 3: EFK 13.8 PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)
Chaetophoraceae 1%
Achnanthaceae 21%
Cymbellaceae 4%
Fragilariaceae 2%
Gomphonemaceae 9%
Naviculaceae 15%
Nitzschiaceae 8%
Oscillatoriaceae 12%
Oocystaceae / Tetrasporaceae 28%

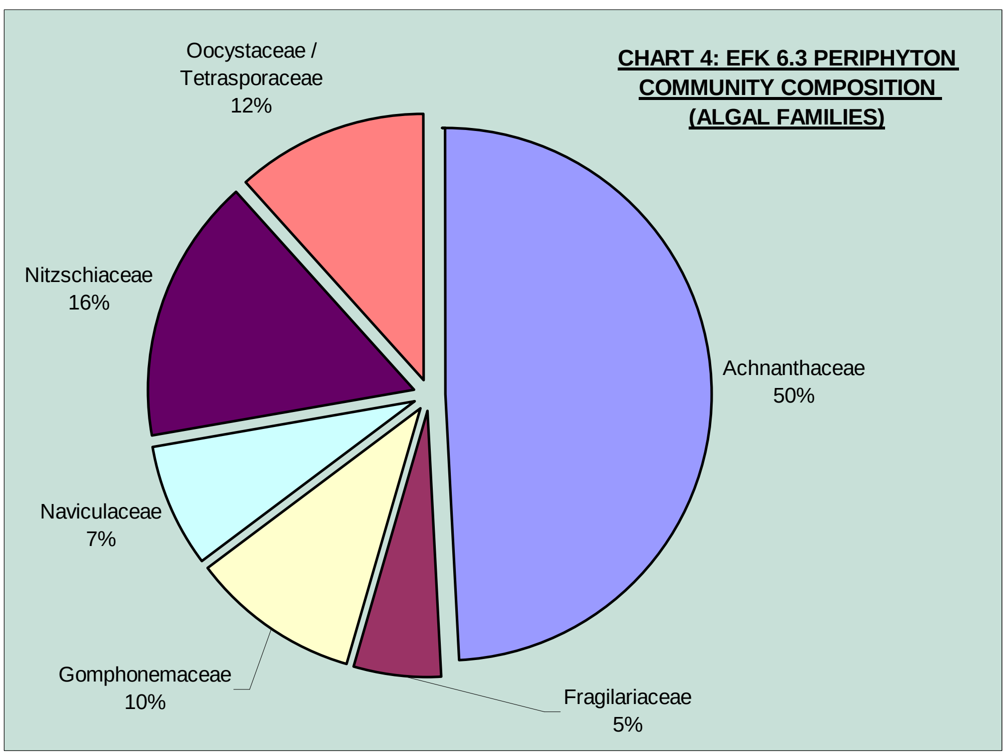


CHART 4: EFK 6.3 PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)
Oocystaceae / Tetrasporaceae 12%
Nitzschiaceae 16%
Achnanthaceae 50%
Naviculaceae 7%
Gomphonemaceae 10%
Fragilariaceae 5%

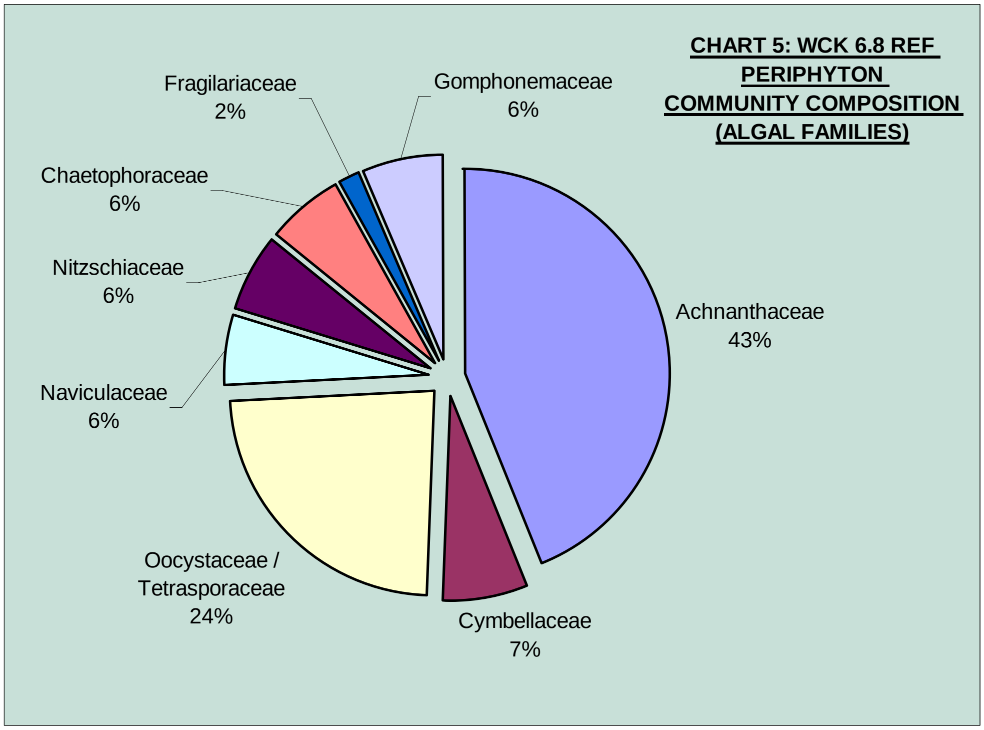
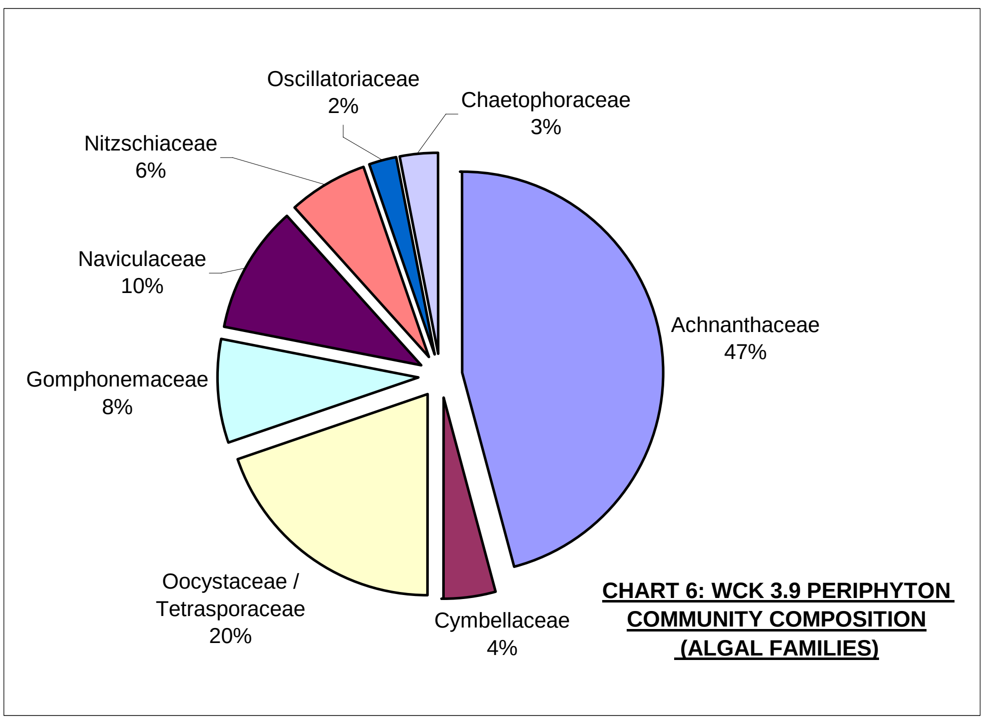
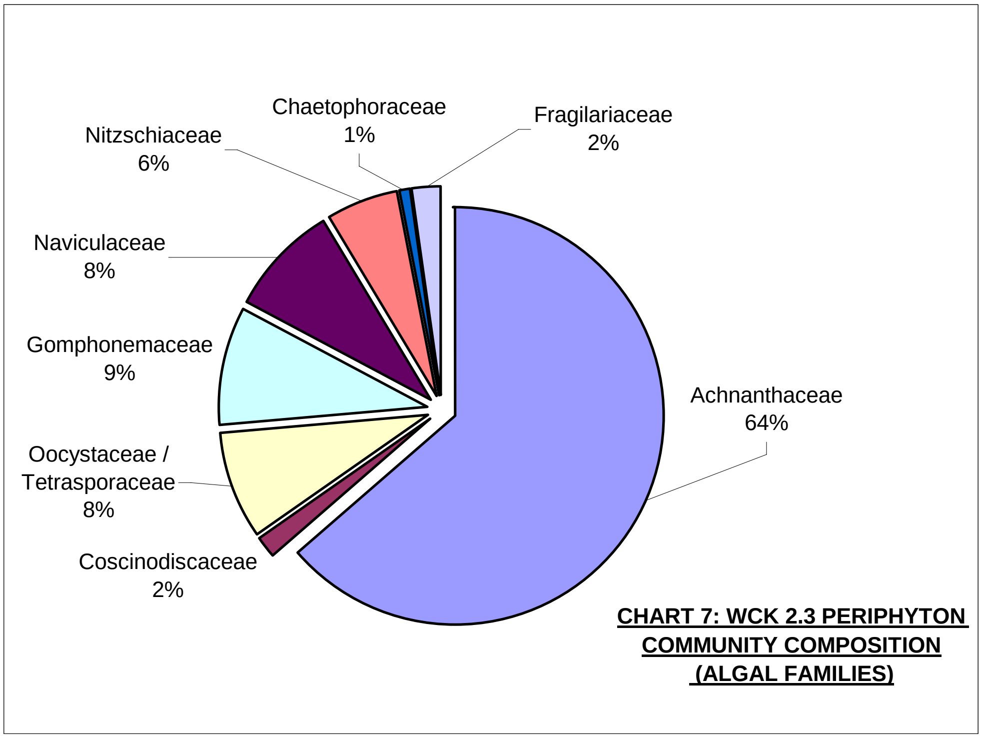
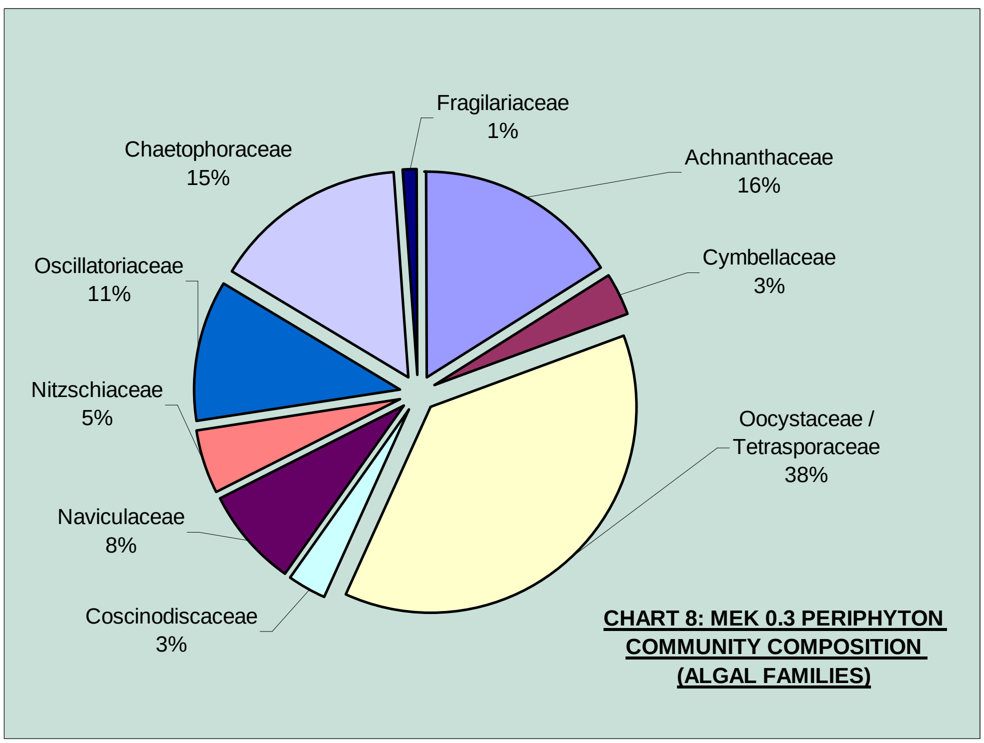


CHART 5: WCK 6.8 REF PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)
Fragilariaceae 2%
Gomphonemaceae 6%
Chaetophoraceae 6%
Nitzschiaceae 6%
Naviculaceae 6%
Achnanthaceae 43%
Oocystaceae / Tetrasporaceae 24%
Cymbellaceae 7%


Oscillatoriaceae 2%
Chaetophoraceae 3%
Nitzschiaceae 6%
Naviculaceae 10%
Gomphonemaceae 8%
Achnanthaceae 47%
Oocystaceae / Tetrasporaceae 20%
Cymbellaceae 4%
CHART 6: WCK 3.9 PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)


Chaetophoraceae
1%
Fragilariaceae
2%
Nitzschiaceae
6%
Naviculaceae
8%
Gomphonemaceae
9%
Achnanthaceae
64%
Oocystaceae /
Tetrasporaceae
8%
Coscinodiscaceae
2%
CHART 7: WCK 2.3 PERIPHYTON
COMMUNITY COMPOSITION
(ALGAL FAMILIES)


Fragilariaceae
1%
Chaetophoraceae
15%
Achnanthaceae
16%
Cymbellaceae
3%
Oscillatoriaceae
11%
Nitzschiaceae
5%
Oocystaceae /
Tetrasporaceae
38%
Naviculaceae
8%
Coscinodiscaceae
3%
CHART 8: MEK 0.3 PERIPHYTON
COMMUNITY COMPOSITION
(ALGAL FAMILIES)

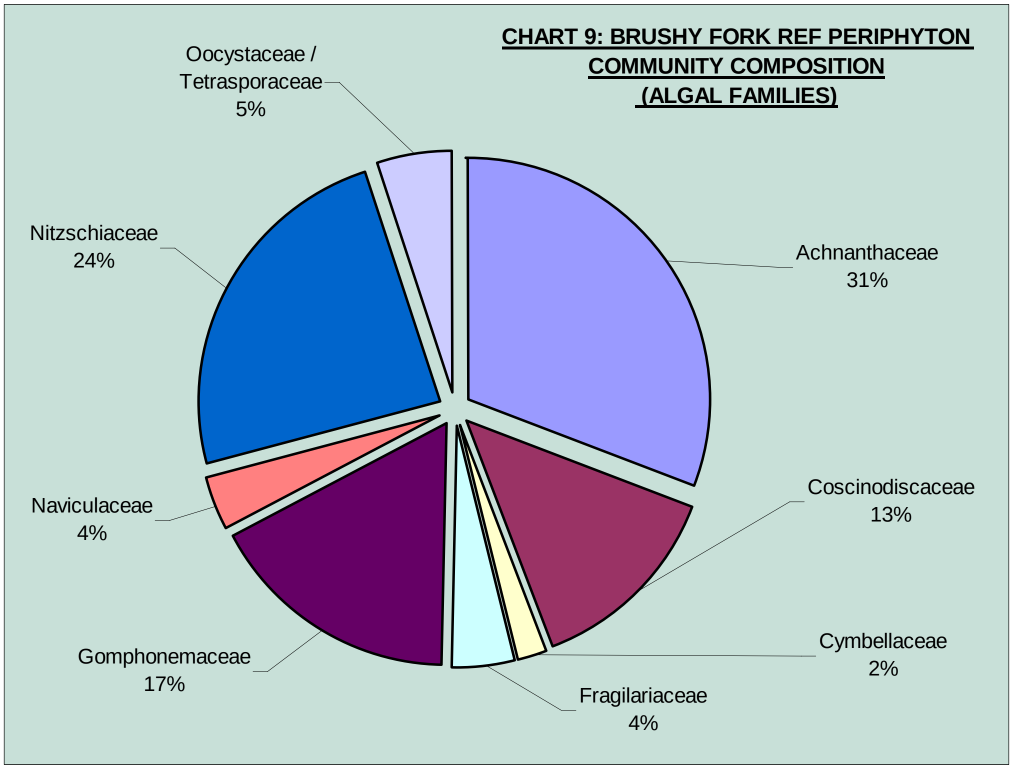
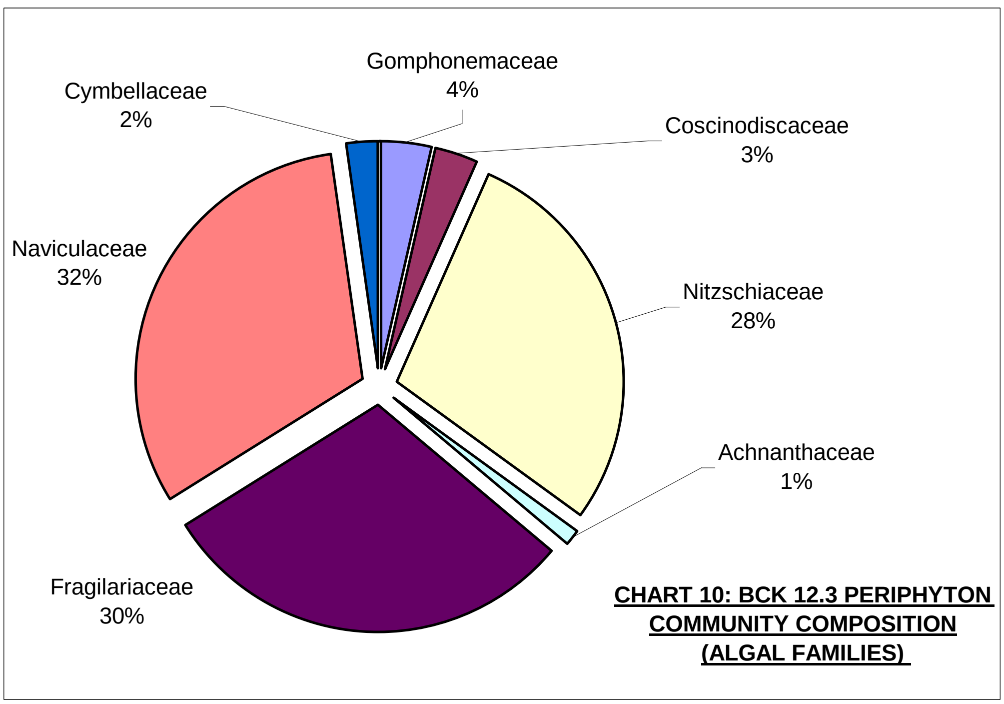


CHART 9: BRUSHY FORK REF PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)
Oocystaceae / Tetrasporaceae 5%
Achnanthaceae 31%
Nitzschiaceae 24%
Coscinodiscaceae 13%
Naviculaceae 4%
Cymbellaceae 2%
Gomphonemaceae 17%
Fragilariaceae 4%


Gomphonemaceae 4%
Cymbellaceae 2%
Coscinodiscaceae 3%
Naviculaceae 32%
Nitzschiaceae 28%
Achnanthaceae 1%
Fragilariaceae 30%
CHART 10: BCK 12.3 PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)

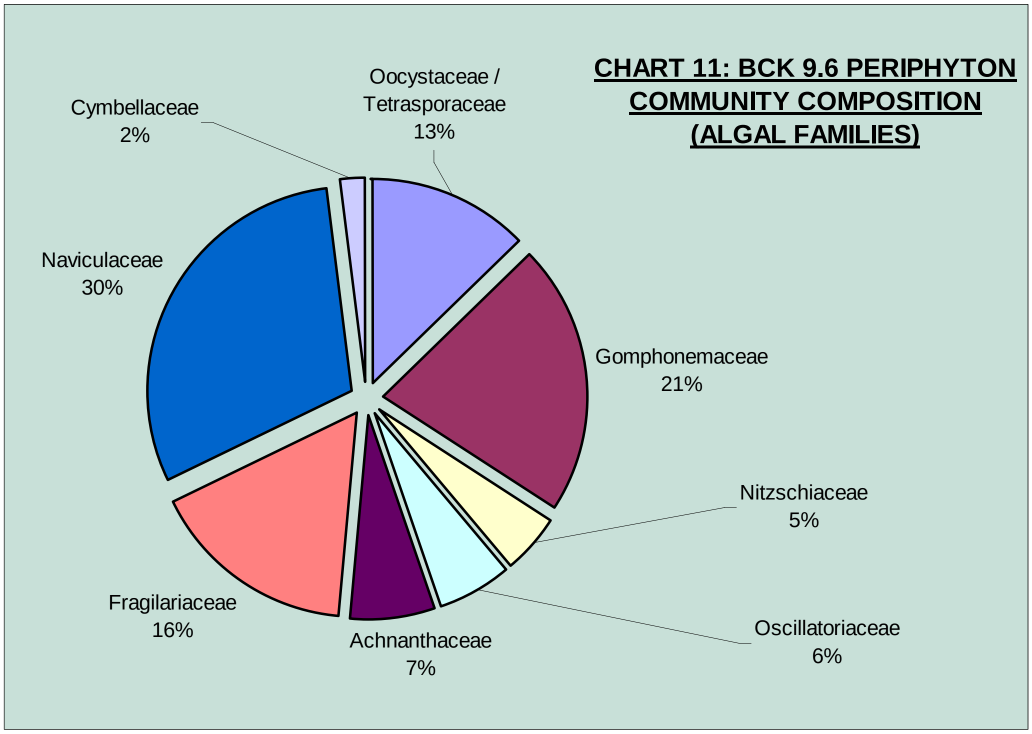
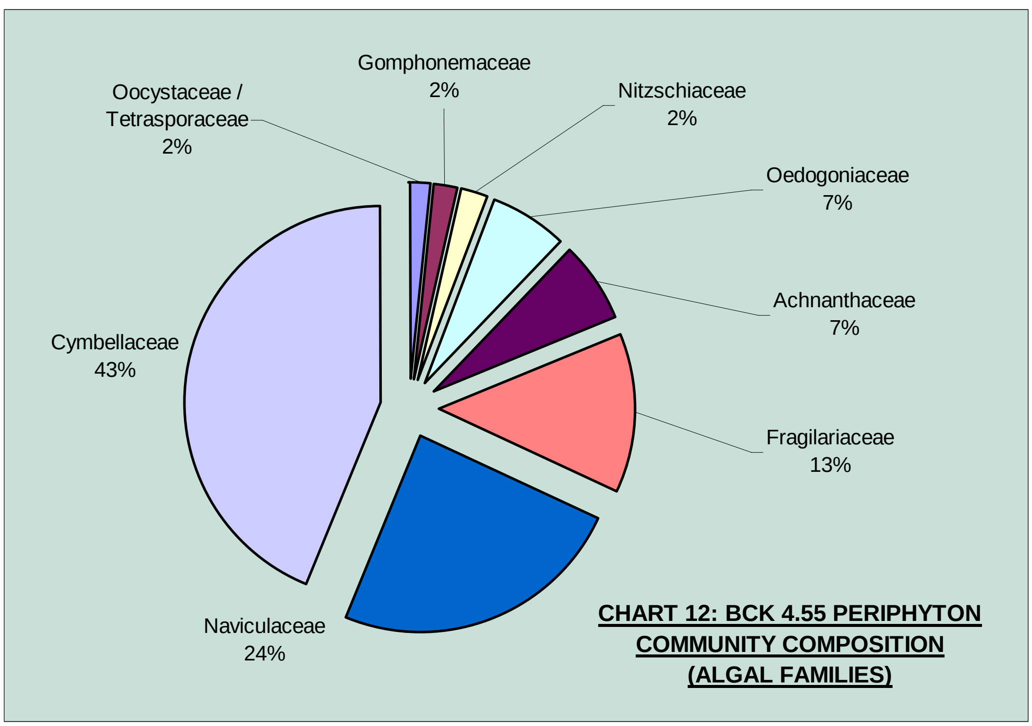


CHART 11: BCK 9.6 PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)
Oocystaceae / Tetrasporaceae 13%
Cymbellaceae 2%
Naviculaceae 30%
Gomphonemaceae 21%
Nitzschiaceae 5%
Oscillatoriaceae 6%
Fragilariaceae 16%
Achnanthaceae 7%


Gomphonemaceae 2%
Oocystaceae / Tetrasporaceae 2%
Nitzschiaceae 2%
Oedogoniaceae 7%
Achnanthaceae 7%
Cymbellaceae 43%
Fragilariaceae 13%
Naviculaceae 24%
CHART 12: BCK 4.55 PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)

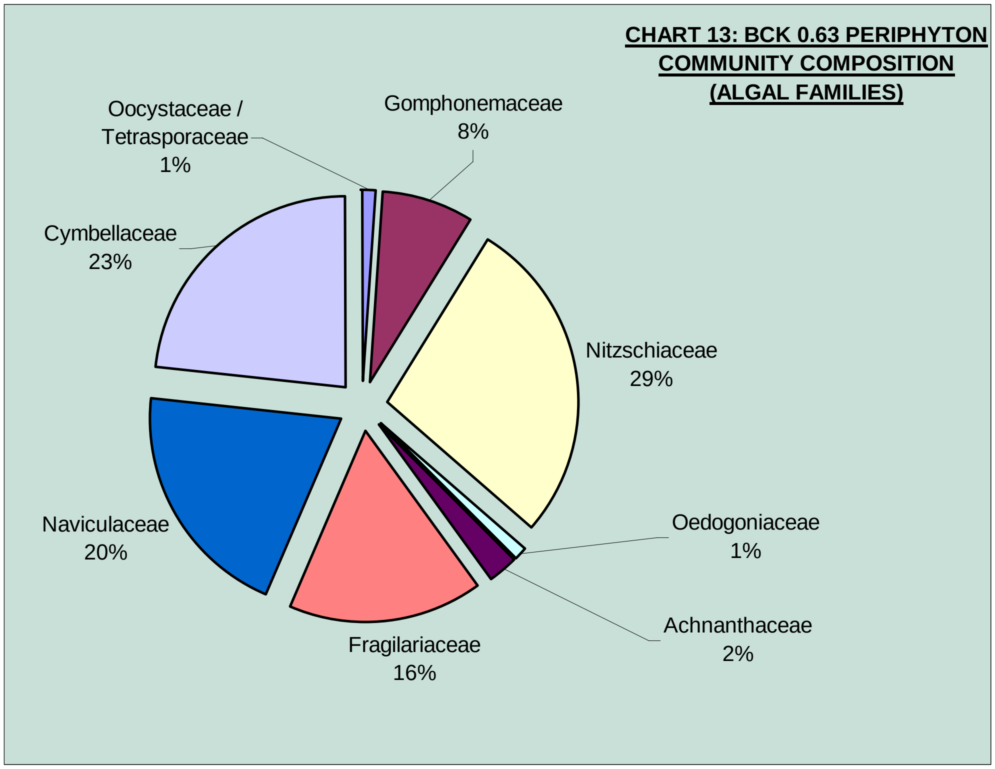
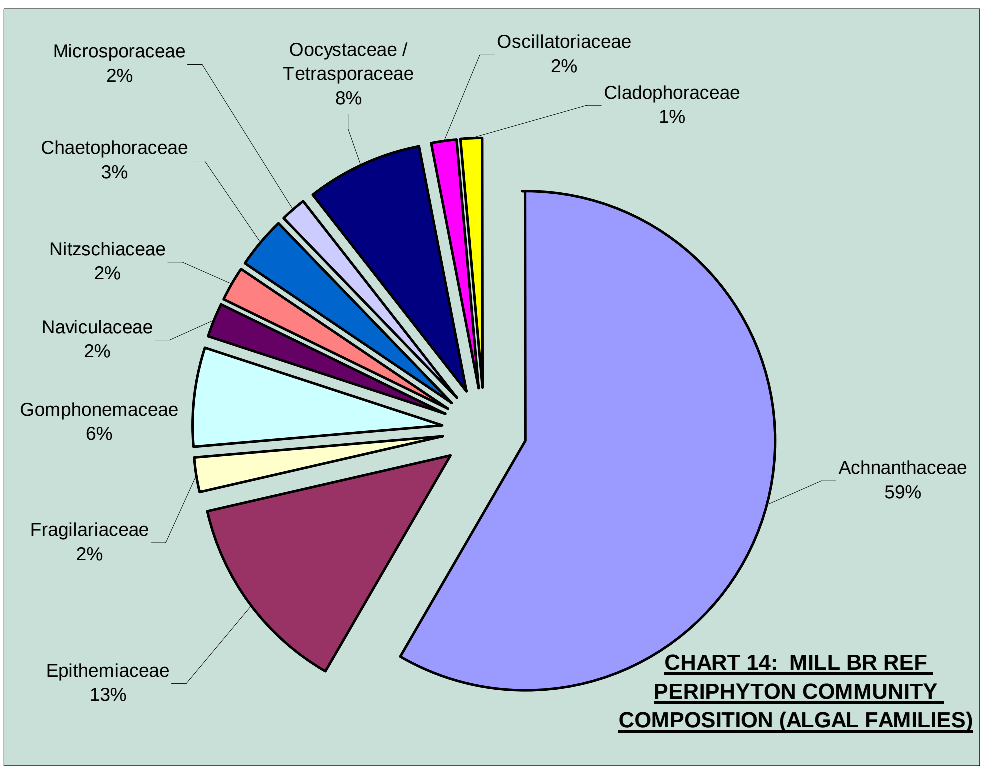


CHART 13: BCK 0.63 PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)
Oocystaceae / Tetrasporaceae 1%
Gomphonemaceae 8%
Cymbellaceae 23%
Nitzschiaceae 29%
Naviculaceae 20%
Oedogoniaceae 1%
Achnanthaceae 2%
Fragilariaceae 16%


Microsporaceae 2%
Oocystaceae / Tetrasporaceae 8%
Oscillatoriaceae 2%
Cladophoraceae 1%
Chaetophoraceae 3%
Nitzschiaceae 2%
Naviculaceae 2%
Gomphonemaceae 6%
Achnanthaceae 59%
Fragilariaceae 2%
Epithemiaceae 13%
CHART 14: MILL BR REF PERIPHYTON COMMUNITY COMPOSITION (ALGAL FAMILIES)

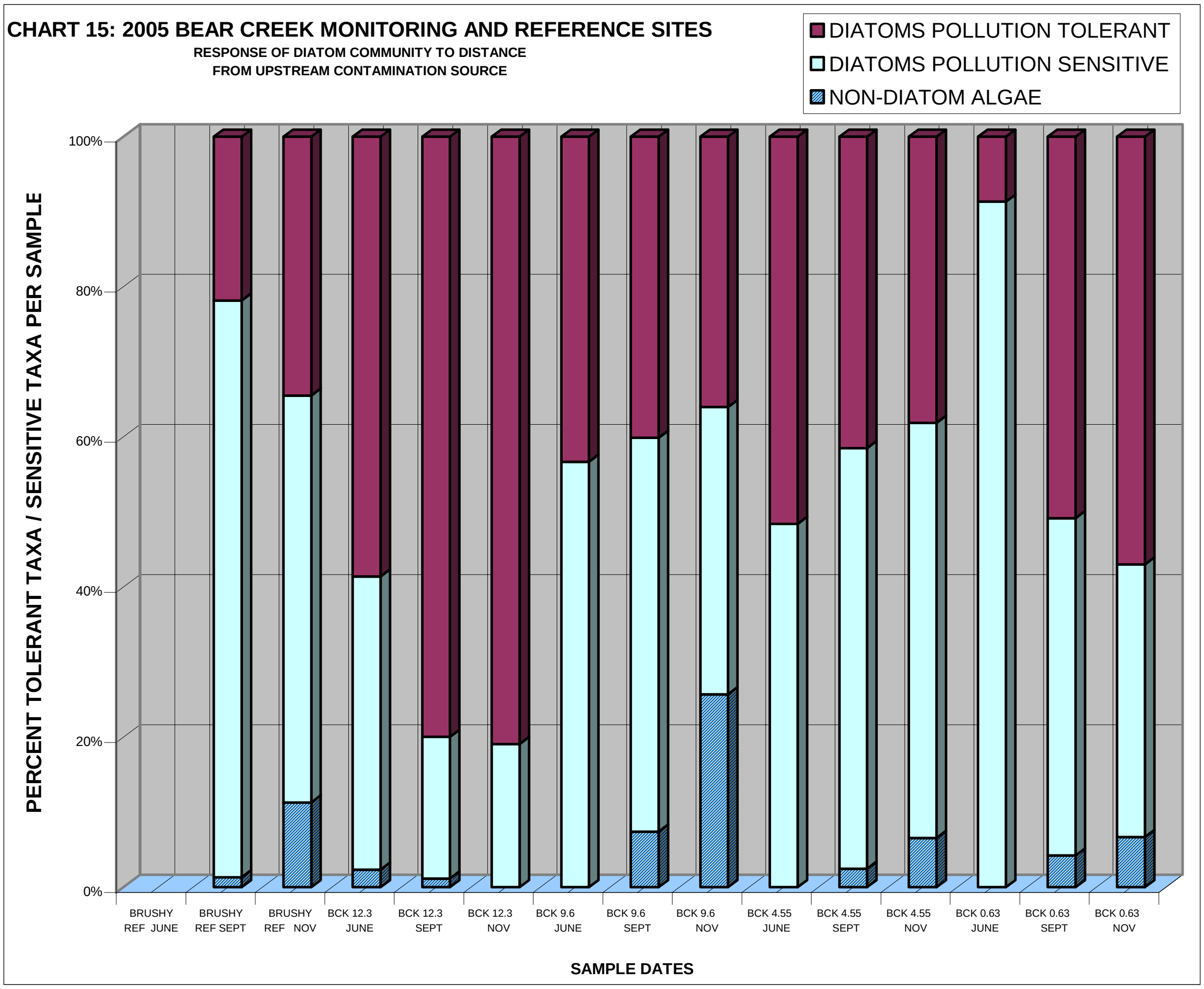


Chart 15: 2005 Bear Creek Monitoring and Reference Sites: Response of Diatom Community to Distance From Upstream Contamination Source

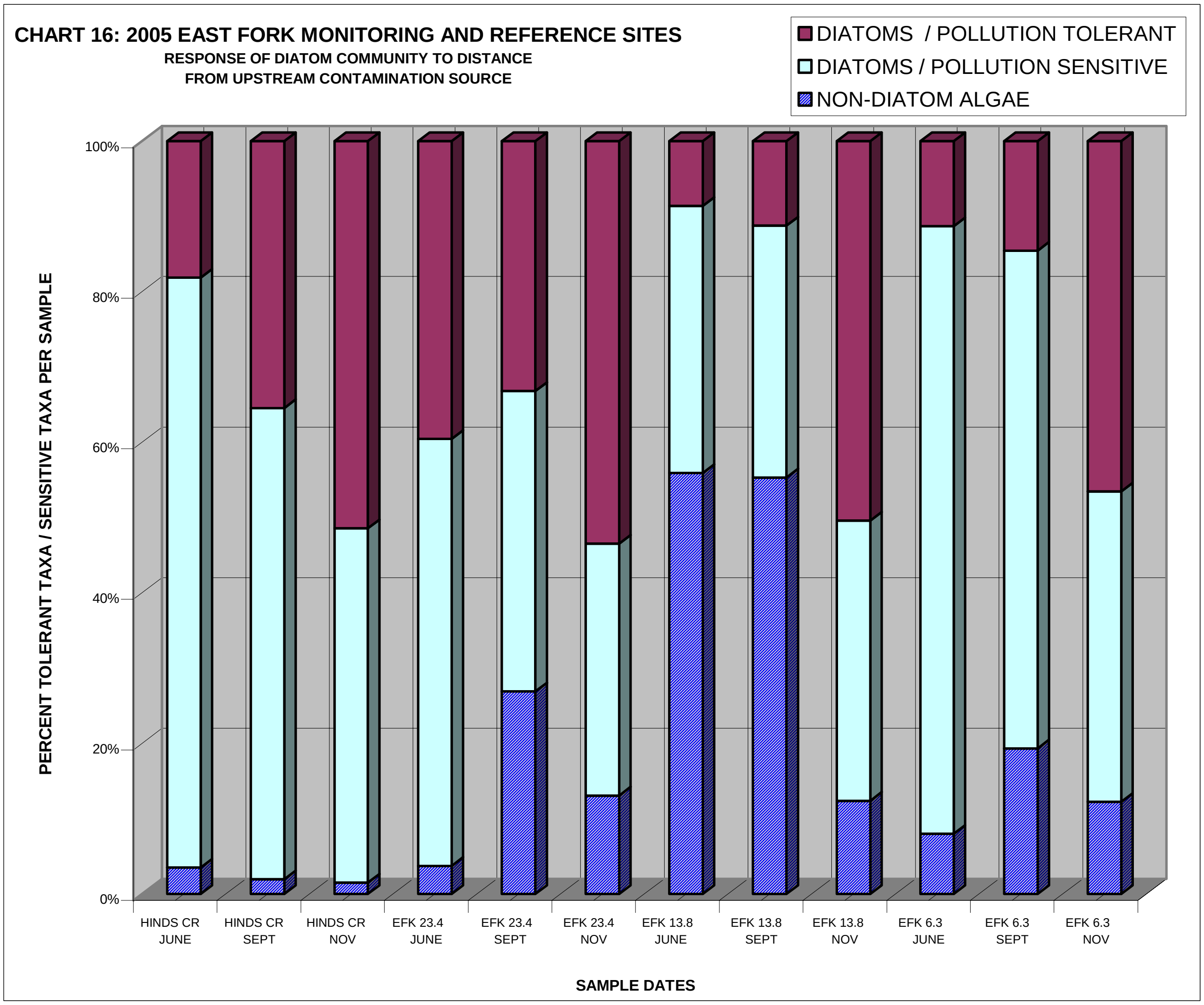


Chart 16: 2005 East Fork Monitoring and Reference Sites: Response of Diatom Community To Distance From Upstream Contamination Source

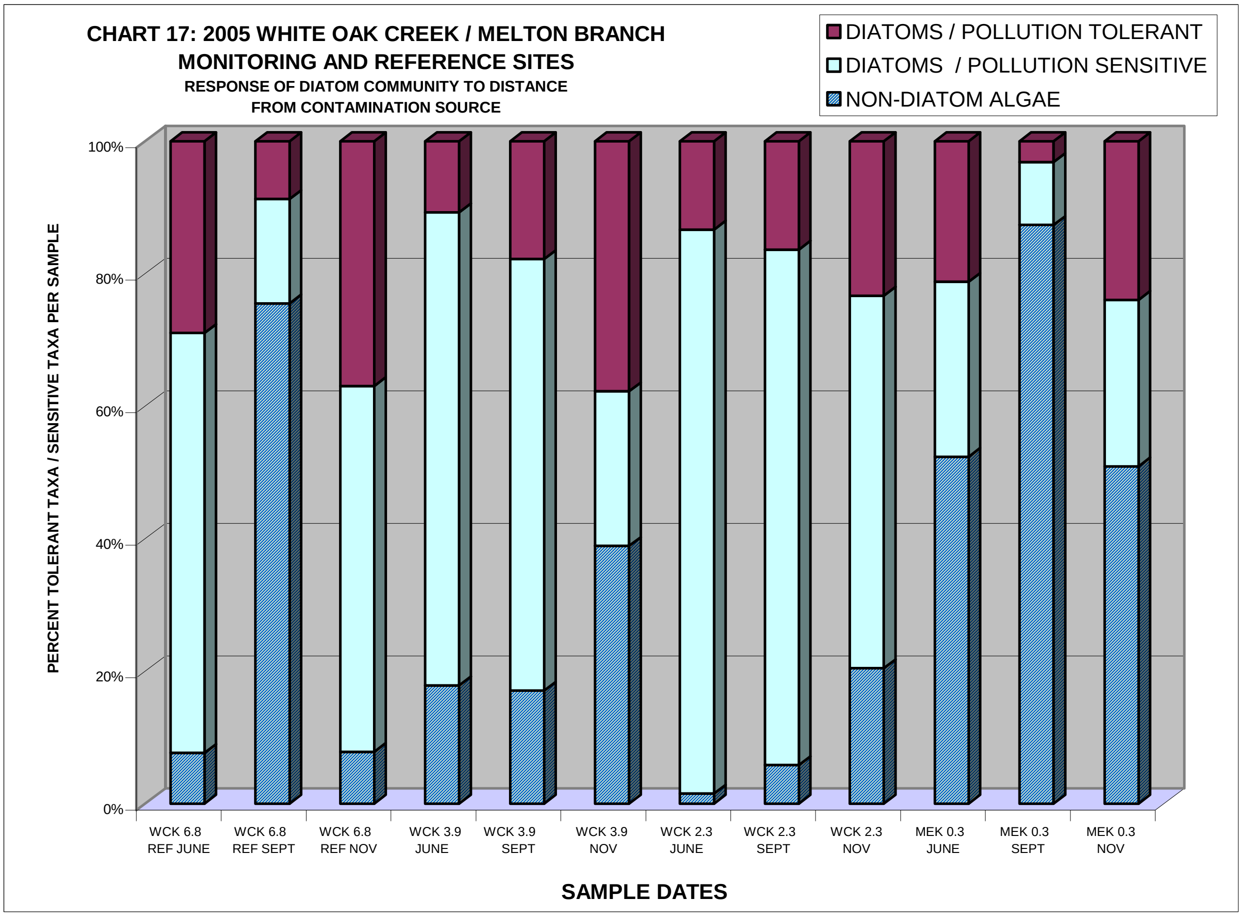


Chart 17: 2005 White Oak Creek/Melton Branch Monitoring and Reference Sites: Response of Diatom Community to Distance From Contamination Source

References:

Adams, S. M. 2001. *Biomarker/bioindicator response profiles of organisms can help differentiate between sources of anthropogenic stressors in aquatic ecosystems*. Biomarkers 6:33-44.

AJA Technical Services, Inc. 1999. *Groundwater Protection Program Calendar Year 1998: Evaluation of Ground water and Surface Water Quality Data for the Bear Creek Hydrogeologic Regime at the U. S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee*. Prepared for Lockheed Martin Energy Systems, Inc. (Y/SUB/99-MVM64V/4).

Alberts, J. J., L. J. Tilly, and T. J. Vigerstad. 1979. *Seasonal cycling of cesium-137 in a reservoir*. Science 203:649-651.

Bahls, L. L. 1993. *Periphyton Bioassessment Methods for Montana Streams*. Dept. of Health and Environmental Sciences, Water Quality Bureau, Helena, MT.

Barbour, M.T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. *Rapid Bioassessment for use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish.* Second Edition. EPA 841-B-99-002. Environmental Protection Agency. Washington, D.C.

Brown, J., A. Hosseini, P. Borretzen, and M. Iosjpe. 2003. *Environmental impact assessments for the marine environment – transfer and uptake of radionuclides*. Stralevern Report. Norwegian Radiation Protection Authority. Osteras, Norway.

Brumley, J., G. Pond, & M. Compton. 2004. *Kentucky's Experience with Using Diatoms for Bioassessment and Assessing Nutrient Impacts*. Kentucky Division of Water. http://www.epa.gov/region5/water/wqb/pdf/brumley_presentation.pdf

Coste, M., C. Boca, and A. Dauta. 1991. *Use of algae for monitoring rivers in France*. B. A. Whitton, E. Rott, and G. Friedrich, editors. *Use of algae for monitoring rivers*. Institute of Botany, University of Inssbruck, Innsbruck, Austria.

Deniseger, J., A. Austin, and W. P. Lucey. 1986. *Periphyton communities in a pristine mountain stream above and below heavy metal mining operations*. Freshwater Biology 16:209-218.

Dixit, S. S., Smol, J. P., Kingston, J. C., and D. F. Charles. 1992. *Diatoms: powerful indicators of environmental change*. Environmental Science Technology 26:23-33.

EPA. 1998. *Rapid Bioassessment Protocols for Use in Streams and Rivers: Periphyton Protocols.* U.S. Environmental Protection Agency.

Fore, L. A., and C. Grafe. 2002. *Using diatoms to assess the biological condition of large rivers in Idaho (USA*). Freshwater Biology 47:2015-2037.

Genter, R. B., D. S. Cherry, E. P. Smith, and J. Cairns, Jr. 1988. *Attached-algal abundance altered by individual and combined treatments of zinc and pH.* Environmental Toxicology and Chemistry 7:723-733.

Gold, C., A. Feurtet-Mazel, M. Coste, and A. Boudou. 2002. *Field transfer of periphytic diatom communities to assess short-term structural effects of metals (Cd, Zn) in rivers*. Water Research 36:3654-3664.

Gold, C., A. Feurtet-Mazel, M. Coste, and A. Boudou. 2003. *Impacts of Cd and Zn on the development of periphytic diatom communities in artificial streams located along a river pollution gradient*. Archives of Environmental Contamination and Toxicology 44:189-197.

Hill, B. H., A. T. Herlihy, P. R. Kaufmann, R. J. Stevenson, F. H. McCormick, and C. B. Johnson. 2000. *Use of periphyton assemblage data as an index of biotic integrity*. Journal of the North American Benthological Society 19:50-67.

Hinzman, R. L. 1998. *Third report on the Oak Ridge Y-12 Plant biological monitoring and abatement program for East Fork Poplar Creek*. Report number Y/TS-889. Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, USA.

HSW Environmental Consultants, Inc. 1994. *Calendar Year 1993 Groundwater Quality Report for the Bear Creek Hydrogeologic Regime, Y-12 Plant, Oak Ridge, Tennessee*. Prepared for Lockheed Martin Energy Systems, Inc. (Y/SUB/94-EAQ10C1/P1).

Kelly, M. G., C. J. Penney, and B. A. Whitton. 1995. *Comparative Performance of Benthic Diatom Indices Used to Assess River Water Quality*. Hydrobiologia 302: 179-188.

Kolkwitz, R. and Marsson, M. 1908. *Berichte Der Deutschen Botanischen Gesellschaft*. 26: 505-519.

Lange-Bertalot H. 1979. *Pollution and Tolerance of Diatoms as a criterion of water quality estimation.* Nova Hedwigia 64: 285-304.

Lowe, R. L., B. H. Rosen, and G. W. Fairchild. 1984. *Endosymbiotic blue-green algae in freshwater diatoms: an advantage in nitrogen poor habitats*. Journal of Phycology 20:24-30.

Mayer, P. M., and S. M. Galatowitsch. 2001. *Assessing ecosystem integrity of restored wetlands from species production-diversity relationships*. Hydrobiologia 443:177-185.

McFarland, B. H., B. Hill, and W. T. Willingham. 1997. *Abnormal Fragilaria spp. (Bacillariophyceae) in streams impacted by mine drainage.* Journal of Freshwater Ecology 12:141-149.

Medley, C. N., and W. H. Clements. 1998. *Responses of diatom communities to heavy metals in streams: The influence of longitudinal variation*. Ecological Applications 8:631-644.

Neal, E. C., B. C. Patten, and C. E. DePoe. 1967. *Periphyton growth on artificial substrates in a radioactively contaminated lake*. Ecology 48:918-923.

Patrick, R., and C. W. Reimer. 1966. *The diatoms of the United States, exclusive of Alaska and Hawaii.* Academy of Natural Sciences, Monograph Number 13. Philadelphia, PA.

Patrick, R. 1973. *Use of Algae, Especially Diatoms, in the Assessment of Water Quality*, Biological Methods for the Assessment of Water Quality. Pg. 76-95. J. Cairns and K. I. Dickson, editors. ASTM, Philadelphia, PA.

Patrick, R., and C. W. Reimer. 1975. *The diatoms of the United States.* Volume 2, Part 1. Academy of Natural Sciences, Monograph Number 13. Philadelphia, PA.

Porter, S. D., T. F. Cuffney, M. E. Gurtz, and M. R. Meador. 1993. *Methods for collecting algal samples as art of the National Water-Quality Assessment Program (NAWQA).* U.S. Department of the Interior. U.S. Geological Survey Open File Report 93-409. Raleigh, North Carolina.

Prescott, G. W. 1978. *How to know the freshwater algae*. 3rd edition. WCB McGraw-Hill. Boston, MA.

Prygiel, J., and M. Coste. 1993. *The assessment of water quality in the Artois-Picardie water basin (France) by the use of diatom indices*. Hydrobiologia 269:343-349.

Round, F. E. 1991. *Diatoms in river water monitoring studies*. Journal of Applied Phycology 3:129-145.

Ruggiu, D., A. Luglie, A. Cattaneo, and P. Panzani. 1998. *Paleoecological evidence for diatom response to metal pollution in Lake Orta (N. Italy)*. Journal of Paleolimnology 20:333-345.

Sansone, U., M. Belli, Z. Jeran, V. V. Kanivets, J. Radojko, M. Riccardi, and O. V. Voitsekhovitch. 2002. *Suspended particle adhesion on aquatic plant surfaces: Implications for* ^{137}*Cs and* ^{133}*Cs uptake rates and water-to-plant concentration ratios.* Journal of Environmental Radioactivity 59:257-271.

Scott, J. T., R. D. Doyle, and C. T. Filstrup. 2005. *Periphyton nutrient limitation and nitrogen fixation potential along a wetland nutrient-depletion gradient*. Wetlands 25:439-448.

Smith, G. M. 1950. *The freshwater algae of the United States*. 2nd edition. McGraw-Hill Book Company. New York, NY.

Smith, V. H., G. D. Tilman, and J. C. Nekola. 1999. *Eutrophication: impacts of excess nutrient inputs on freshwater, marine,and terrestrial ecosystems*. Environmental Protection 100:179-196.

Stevenson, R. J., and R. L. Lowe. 1986. *Sampling and interpretation of algal patterns for water quality assessments*. *In* B. G. Isom, editor. *Rationale for sampling and interpretation of ecological data in the assessment of freshwater ecosystems*. American Society of Testing and Materials. ASTM 894:118-149.

Stevenson, R. J., and Y. Pan. 1999. *Assessing environmental conditions in rivers and streams with diatoms. In*: E. F. Stoermer and J. P. Smol, editors. *The diatoms: Applications to the Environmental and Earth Sciences.* Cambridge University Press, Cambridge, UK.

Stevenson, R. Jan, P. V. McCormick, & R. Frydenborg. 2001. *Using Algae to Assess Environmental Conditions in Wetlands.* Dept. of Zoology, Michigan State University. http://www.epa.gov/owow/wetlands/bawwg/natmtg2001/stevenson/stevenson.pdf

Stevenson, R. Jan, P. V. McCormick, & R. Frydenborg. 2002. *Methods for evaluating wetland condition: (#11) using algae to assess environmental conditions in wetlands*. U. S. Environmental Protection Agency. EPA-822-R-02-021. Office of Water, Washington, DC.

Stoermer, E.F., and Smol, J.P. 1999. *The Diatoms: Applications for the Environmental and Earth Sciences*. Cambridge University Press, Cambridge, U.K.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

U. S. Environmental Protection Agency. 1998. *Lake and reservoir bioassessment and biocriteria*. Technical Guidance Document 841-B-98-007. Office of Water, Washington, DC.

UT-Battelle, LLC. 2002. *Oak Ridge Reservation Annual Site Environmental Report for 2001*. DOE/ORO/2133. UT-Battelle, LLC, Oak Ridge National Laboratory, Oak Ridge, TN.

Vannote, G. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. *The river continuum concept*. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

Vitousek, P. M., H. A. Mooney, J. Lubchenko, and J. Melillo. 1997. *Human domination of Earth's ecosystems.* Science 277:494-499.

Ward, J. V., and J. A. Stanford. 1983. *The serial discontinuity concept of river ecosystems*. *In*: T. D. Fontaine, and S. M. Bartell, (Ed.) *Dynamics of lotic ecosystems*, 29-42. Ann Arbor Science Publications. Ann Arbor, MI.

Wehr, J. D., and R. G. Sheath. 2003. *Freshwater algae of North America: Ecology and classification.* Academic Press (Elsevier Science). New York, NY.

CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

Fish Tissue Monitoring

Principal Author: Roger Petrie

Abstract

The Tennessee Department of Environment and Conservation (TDEC) posts warning signs on streams or lakes in which public health is endangered. In an effort to evaluate the extent to which fish in Watts Bar Reservoir pose a risk to human health, a cooperative sampling and analysis project was undertaken. This was a joint effort between TDEC, the Tennessee Valley Authority, and the Oak Ridge National Laboratory. Various species of fish were collected from several sites on Watts Bar Reservoir. Adequate numbers of fish were not collected to allow this project to be completed. Of the species that were sampled, the obtained results indicate that the fish have levels of contaminants below those used to post fishing advisories.

Introduction

The Tennessee Department of Environment and Conservation (TDEC) posts warning signs on streams or lakes in which public health is endangered. In Tennessee, the most common reasons for a river or lake to be posted are the presence of sewage bacteria or other contaminants in the water, sediment, or fish of a waterbody.

When fish tissue samples show levels of contaminants higher than established criteria, the waterbody is posted and the public is advised of the risk (TDEC 2003). Approximately 84,100 lake acres and 142 river miles across the state are currently posted due to contaminated fish. Table 1 shows current criteria used for issuing fish consumption advisories in Tennessee.

Table 1: State of Tennessee Fish Tissue Advisory Criteria

Contaminant	Level (mg/kg)
PCBs	1.00
Hg	0.50

An annual fish tissue meeting is held each year to exchange data and coordinate sampling efforts among the organizations that sample fish tissue in Tennessee. The 2005 meeting discussed efforts around the Oak Ridge Reservation (ORR). Review of PCB levels in catfish on Watts Bar Reservoir indicates that these levels have continued to decline over the past several years. Table 2 shows current postings on Watts Bar Reservoir. Since no single agency has the resources to conduct a comprehensive sampling and analysis of fish tissue on Watts Bar Reservoir, a multi-agency effort was conducted, with TVA and ORNL conducting the sampling, and TDEC DOE-O conducting the analysis.

Table 2: Current Fish Advisory Postings on Watts Bar Reservoir

Reservoir	Portion	Pollutant	Species
Watts Bar	Tennessee River arm	PCBs	Catfish, striped bass, & hybrid (striped bass-white bass) should not be eaten. Precautionary advisory for white bass, sauger, carp, smallmouth buffalo, and largemouth bass.
Watts Bar	Clinch River arm	PCBs	Striped bass should not be eaten, Precautionary advisory for catfish and sauger.

Methods and Materials

Fish samples were collected by various agencies during the course of their normal collection activities in 2005. Adequate numbers of fish were not collected to allow this project to be completed. Table 3 lists species that were collected and the sites from which they were collected in 2004. Samples were processed in accordance with established protocols (EPA 2000). Analyses for PCBs and mercury were conducted on each sample.

Table 3: 2004 Watts Bar Reservoir Fish Tissue Collections

Site	Species Collected						
TRM 531	C. Catfish	LMB	na	Sm. Buffalo	Striped bass	White bass	Carp
TRM 560.8	C. Catfish	LMB	na	na	na	na	na
TRM 600	C. Catfish	LMB	na	na	na	White bass	na
CRM 19	C. Catfish	LMB	Sauger	na	Striped bass	na	na

C. Catfish = Channel Catfish
LMB = Largemouth Bass
Sm. Buffalo = Smallmouth Buffalo
na – Insufficient specimens were collected to complete a sample

Attempts were made to collect all species for which fish advisories are currently in place on Watts Bar Reservoir, but due to resource and time frame restrictions, it was not always possible to obtain a sufficient sample at all the sites. No hybrid (striped bass-white bass) were collected in sufficient quantities to enable analysis.

Results and Discussion

Results of PCB analysis are shown in Table 4. These results are all below the current criteria of 1.00 mg/kg used for issuing PCB fish consumption advisories in Tennessee.

Table 4: Results of 2004 PCB Analysis for Watts Bar Reservoir Fish (mg/kg)

Site	C. Catfish	LMB	Sauger	Sm. Buffalo	Striped Bass	White Bass	Carp
TRM 531	0.3[a] 0.18[b]	U[a]	[e]	U[d]	U[d]	U[d]	U[d]
TRM 560.8	0.3[a]	0.3[a]	[e]	[e]	[e]	[e]	[e]
TRM 600	0.3[a]	0.3[a] U[d]	[e]	[e]	[e]	0.44[d]	[e]
CRM 19	0.21[b]	U[d]	0.19[d]	[e]	0.10[b,c]	[e]	[e]

[a] – TVA Results
[b] – ORNL Results
[c] – Collected at CRM 3.0
[d] – TDEC DOE-O Results
[e] – Insufficient specimens were collected to complete a sample
U - Undetected

Results of mercury analysis are shown in Table 5. These results are all below the current criteria of 0.5 mg/kg used for issuing mercury fish consumption advisories in Tennessee. In fact, with the exception of channel catfish from TRM 531, all results were below the EPA recommended water quality criteria of 0.3 mg/kg (EPA 2001).

Table 5: Results of 2004 Mercury Analysis for Watts Bar Reservoir Fish (mg/kg)

Site	C. Catfish	LMB	Sauger	Sm. Buffalo	Striped Bass	White Bass	Carp
TRM 531	0.3[a] 0.29[b]	0.22[a]	[e]	0.19[d]	0.07[d]	0.05[d]	0.19[d]
TRM 560.8	0.14[a]	0.18[a]	[e]	[e]	[e]	[e]	[e]
TRM 600	0.14[a]	0.14[a] 0.10[d]	[e]	[e]	[e]	0.06[d]	[e]
CRM 19	0.14[b]	0.26[a] 0.29[d]	0.07[d]	[e]	0.09[b,c]	[e]	[e]

[a] – TVA Results
[b] – ORNL Results
[c] – Collected at CRM 3.0
[d] – TDEC DOE-O Results
[e] – Insufficient specimens were collected to complete a sample

Conclusion

Based on the results obtained in this sampling, it appears that there are no levels of contaminants that would require posting of fish advisories on Watts Bar Reservoir. Requirements are such that removing a fish advisory requires multiple samples over a period of years. If this cooperative effort continues and levels remain at those observed for this sampling effort, there is a possibility that at least some of the fish advisories on Watts Bar Reservoir could be removed.

References

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee*. Oak Ridge, Tennessee. 2001.

Tennessee Department of Environment and Conservation. 2003. *Rules Of the Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control. Chapter 1200-4-3. General Water Quality Criteria.* State of Tennessee.

Thomasson, D. A. 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

U.S. Environmental Protection Agency. 2000. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume 1: Fish Sampling and Analysis. Third Edition.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 823-B-00-007.

U.S. Environmental Protection Agency. 2001. *Water Quality Criterion for the Protection of Human Health: Methylmercury*. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-823-R-01-001.

Chapter 2 BIOLOGICAL/FISH AND WILDLIFE

Canada Geese Monitoring

Principal Author: Roger Petrie

Abstract

On June 23 and 24, 2005, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) conducted oversight of the annual Canada Geese (Branta canadensis) monitoring project on the Oak Ridge Reservation (ORR). The objective of this study was to determine if geese are becoming contaminated on the ORR. The captured geese were transported to the Tennessee Wildlife Resources Association (TWRA) game check station on Bethel Valley Road and tested for radioactive contamination. None of the geese captured at this year showed elevated gamma counts above the 5pCi/g game release level. Since no contaminated geese were captured, the DOE-Oversight Division did not conduct additional offsite sampling of Canada Geese.

Introduction

A large population of Canada geese, both resident and transient, frequents the Oak Ridge Reservation (ORR) (Crabtree 1998). The thriving goose population in this area makes this animal an easily accessible food for area residents. Geese with elevated levels of Cs137 in muscle tissue have been found on the ORR (MMES 1987 and Loar 1994). Studies in the 1980s demonstrated that geese associated with the contaminated ponds/lakes on the ORR can accumulate radioactive contaminants quickly and that contaminated geese frequent off site locations (Loar 1990, Waters 1990, MMES 1987).

Every year the Department of Energy (DOE) and Tennessee Wildlife Resource Agency (TWRA) capture geese on the ORR during the annual "Goose Roundup" and perform whole body counts on them to determine if the birds are radioactively contaminated. During the 1998 "Goose Roundup," 38 geese at ORNL contained Cesium 137 concentrations that exceeded the game release limit of 5 pCi/g (ORNL 1998). A subsequent study in September 1998 found elevated levels of Cs137 in grass and sediment at two reaches of White Oak Creek south of 3513 Pond and in grass around the 3524 pond (ORNL 1998). In 2002, three young of the year geese from the west end of ORNL were found to have Cesium 137 levels above the game release level. In 2003 and 2004, no geese were found to have Cesium 137 levels above the game release level.

The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) has a sampling plan that is implemented when geese with elevated gamma readings are detected during the regular "Goose Roundup." If any geese with elevated gamma readings are detected, then arrangements are made to sample geese that are found in the vicinity of the ORR on non-DOE property. This is to determine if contaminated geese are leaving the reservation and are presenting a risk to area hunters.

Results and Discussion

During the 2005 sampling, a total of 295 birds were captured. Most of the adult geese were banded and all were released. A subsample of twenty birds from each site were given total body counts for five minutes with a sodium iodide detector at the TWRA game checking facility on Bethel Valley

Road. None of the birds analyzed had levels of gamma above the 5pCi/g game release level. Table 1 shows results of the 2005 DOE Goose Roundup.

Table 1: 2005 DOE Goose Round-up Results

Site	Date	# Captured	Adults	Juveniles	# > 5pCi/g
ORNL	6/23/05	117	82	35	0
ETTP	6/24/05	126	117	9	0
Clark Center Park	6/24/05	44	44	0	0
Y-12	6/24/05	8	6	2	0
Totals		295	249	46	0

Since none of the birds analyzed showed signs of contamination, no additional offsite sampling was conducted.

Conclusion

Although none of the birds analyzed showed signs of contamination, historical information indicates that this species is still susceptible to contamination from sources on the ORR. It does, however, indicate that there is a reduced likelihood of this situation existing.

References

Ashwood, T.L. ed. 1993. *Seventh Annual Report on the ORNL Biological Monitoring and Abatement Program*, Environmental Sciences Division Publication No. 4074. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Blaylock B. G., M.L. Frank, F.O. Hoffman, L.A. Hook, G.W. Suter, J. A. Watts. 1992. *Screening of Contaminants in Waste Area Grouping 2 at Oak Ridge National Laboratory*, Oak Ridge, Tennessee. ORNL/ER-62/R1, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Crabtree, H., TDEC DOE-Oversight, 1998. Personal communication.

Evans, J., TWRA, Personal communication.

Loar, J. M., ed. 1990*, Fourth Annual Report on the ORNL Biological Monitoring and Abatement Program*, ORNL/TM- (Draft). Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Loar, J. M., ed. 1994. *Fourth Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River*, ORNL/TM-11544. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

MMES 1987, *Environmental Surveillance of the U.S. Department of Energy Oak Ridge Reservation and Surrounding Environs During 1986*, Volume 2: Data Presentation, ES/ESH-1/V2,

ORNL 1994, *Third Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River*. ORNL/TM-11358, Environmental Sciences Division Publication No. 4255.

ORNL 1998. Study Plan and Analysis Results from Contamination Study on Soils and Vegetation Around 3524 and 3513 Ponds, First Creek and White Oak Creek

Thomasson, D. A. 2005. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

Waters, A. E. 1990. *Radioactive and Non-radioactive Contaminants in Migratory and Resident Waterfowl Inhabiting the Oak Ridge Reservation*, East Tennessee, Master of Science Degree Thesis.The University of Tennessee, Knoxville, Tennessee.

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CHAPTER 3 DRINKING WATER

Sampling of Oak Ridge Reservation Potable Water Distribution Systems

Principal Author: Roger Petrie

Abstract

As the three Department of Energy (DOE) Oak Ridge Reservation (ORR) plants become more accessible to the public, the Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division (DOE-O) has expanded its oversight of the DOE facilities' safe drinking water programs. The scope of TDEC DOE-O's independent sampling includes oversight of potable water quality on or impacted by the ORR. TDEC conducted oversight of backflow prevention devices and sanitary surveys at ORR facilities. The results of these inspections revealed that the three reservation systems provide water that meets State regulatory levels. The distribution system at Y-12 does have some deficiencies in their Cross Connection Control Program, as noted in the sanitary survey.

Introduction

Public consumption of the water on the Oak Ridge Reservation (ORR) continues to increase. In order to facilitate technology transfer, work for non-governmental sectors, and utilization of surplus buildings by private companies, security has been relaxed or reprioritized in recent years at some portions of the sites, most notably at East Tennessee Technology Park (ETTP). In turn the composition of the workforce at the ORR has changed substantially. Oak Ridge National Laboratory (ORNL) has always hosted foreign dignitaries and accommodated visiting scientists in an openly cooperative manner. The other two sites, ETTP and Y-12, until recent years, allowed only limited public visitation. Current facility use involves a substantial public presence at ETTP and ORNL, and to a lesser extent at Y-12.

Methods and Materials

Although TDEC will conduct independent sampling when situations indicate that the quality of drinking water in an ORR distribution system may be compromised or that the general integrity of the system is in doubt, the objective of this task was to conduct oversight of all aspects of drinking water supply at the three ORR facilities. The oversight included checking inspection dates on backflow prevention devices as well as attendance at sanitary surveys conducted by personnel from the TDEC Division of Water Supply (DWS). In addition, some random independent checks were made of free residual chlorine levels and bacteriological levels.

Results and Discussion

The Division received copies of the Sanitary Survey results from the Division of Water Supply (DWS) for each of the three ORR facilities. ORNL and ETTP received "APPROVED" ratings for their respective systems. The Y-12 system received a rating of "PROVISIONAL." In addition, Y-12 received a Notice of Violation (NOV) from DWS for deficiencies related to their Cross Connection Control Program.

Also, the upcoming Notice of Violation (NOV) that ETTP will receive was discussed. The NOV pertains to procedural variations that occurred when monthly bacteriological samples were taken. Division of Water Supply personnel at the KEAC had already informed DOE-Oversight of the NOV. The NOV is related to a single occurrence when both monthly bacteriological samples were collected on the same day. Regulations require that the samples be taken on different days. OMI has already altered procedures to reduce the likelihood of this happening again.

On February 28, 2005, DOE-O personnel met with utilities personnel from ORNL. Topic discussed included the status of the concrete storage tank. The selected alternative is to replace this tank with a new 1.5 million gallon tank. Also, the current status of the ORNL Total Trihalomethanes (TTHM) monitoring program was discussed. The program may be used as an example of how to conduct operations to minimize the presence of TTHMs.

On March 14, 2005, DOE-O personnel conducted oversight of the monthly bacteriological sampling at ORNL. ORNL personnel collected three regulatory bacteriological samples and took free residual chlorine readings. All chlorine levels were well above the regulatory limit of 0.2 ppm.

On April 13, 2005, DOE-O personnel met with OMI personnel to discuss the OMI potable water sampling program at ETTP, i.e., their new and improved version of the Bacteriological Sampling Procedures and Types of Sampling protocol for their employees to follow while in the field. Later, Oversight personnel accompanied OMI personnel to four sampling sites: K-1203 sewage treatment plant, K-1430 facility men's room sink, K-1435 TSCA men's change room sink, and the K-220/1225 (centrifuge) men's room sink. Results were within regulatory limits.

On April 27, 2005, division personnel did a follow-up site visit at the location of a 12-inch water line break (sanitary water header that feeds ETTP) which had been repaired and was being back-filled. About 18 feet of pipe was replaced during repairs. Approximately 480.000 gallons of water (~4.8 lbs of chlorine overall) was released when the line ruptured around midnight of the 26th and entered the K-1007-P-5 pond just west of the line breakage; OMI staff tracked down the location of the break in a short time following the failure.

On May 24, 2005, division personnel took a chlorine reading and collected a bacteriological sample at ORNL aquatic ecology men's room (1504). Results were within regulatory limits.

On May 24, 2005, division personnel conducted oversight of routine bacteriological sampling at ORNL. Results were within regulatory limits.

On July 22, 2005, division personnel took free residual chlorine readings at three locations at ORNL. These locations were Bldg 1504, Bldg 1505, and Bldg 2033. Results were within regulatory limits.

On August 1, 2005, division personnel took free residual chlorine readings and bacteriological samples at three locations at ORNL. These locations were (1) New Visitor Center (1st floor, men's room sink), (2) Bldg. 1505/ESD (1st floor, men's room sink), (3) Bldg. 1506 (Plant Ecology Bldg., snack room sink). Results were within regulatory limits.

On September 7, 2005, DOE-O personnel accompanied DWS personnel on the sanitary survey of the Y-12 water distribution system. This survey was conducted as a follow-up to the 2004 Sanitary Survey that resulted in a Notice of Violation being issued to Y-12 for deficiencies in their operation of the distribution system.

The main point of the survey was to review the Y-12 Cross Connection Control (CCC) Plan and the management of backflow prevention devices. The primary points that the State requested that Y-12 address were:

1. Define in the CCC plan who has final authority over operation and maintenance of BFP devices.
2. Provide a complete list of backflow prevention (BFP) devices that notes their general location, inspection dates, and current status.
3. Establish a protocol that will provide complete documentation of all aspects of BFP device inspections and repairs.
4. Conduct an initial hazard analysis to determine the needs for and types of BFP devices required to adequately protect the drinking water supply. Also, to develop an annual process for conducting hazard analyses.

As of this writing, the final status of the Y-12 CCC plan is still pending.

On November 23, 2005, DOE-Oversight personnel sampled three locations at ORNL for free chlorine residual. Results were within regulatory limits.

On November 30, 2005, DOE-O personnel met with the city of Oak Ridge to discuss the potential transfer of the ETTP water treatment plant and distribution system to the city of Oak Ridge. Potential problems associated with the transfer were discussed including the prevalence of groundwater contamination at the site, age of the infrastructure, cross connection between the potable system and the firewater system, and the future disposition of the system.

The city of Oak Ridge provided a copy of the proposed agreement between the City and DOE. TDEC DOE-O provided city of Oak Ridge with a copy of the Special ETTP Water Sampling Report (November 2000), a safety publication concerning the operation of a distribution system on a contaminated site, a cross connection control magazine, and maps showing the extent of groundwater contamination on the site (Figures 1 and 2).

Figure 1. ETTP Groundwater Plumes (February 1995)

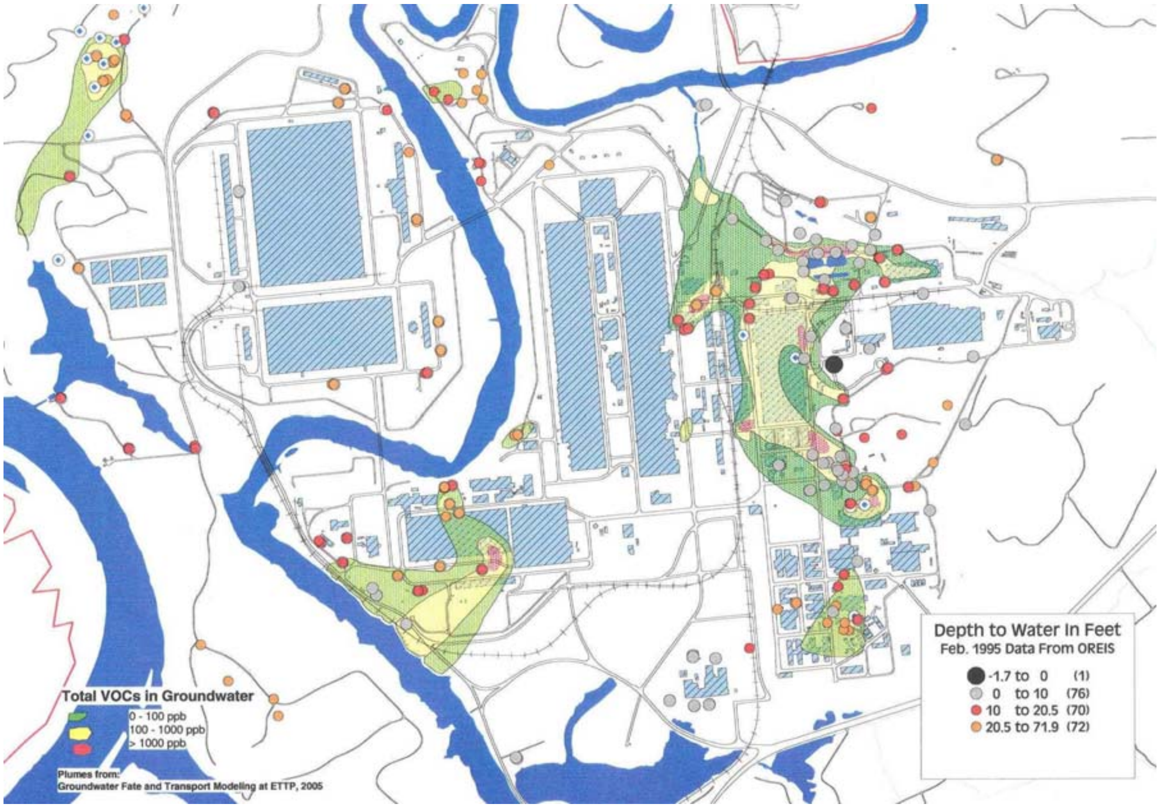
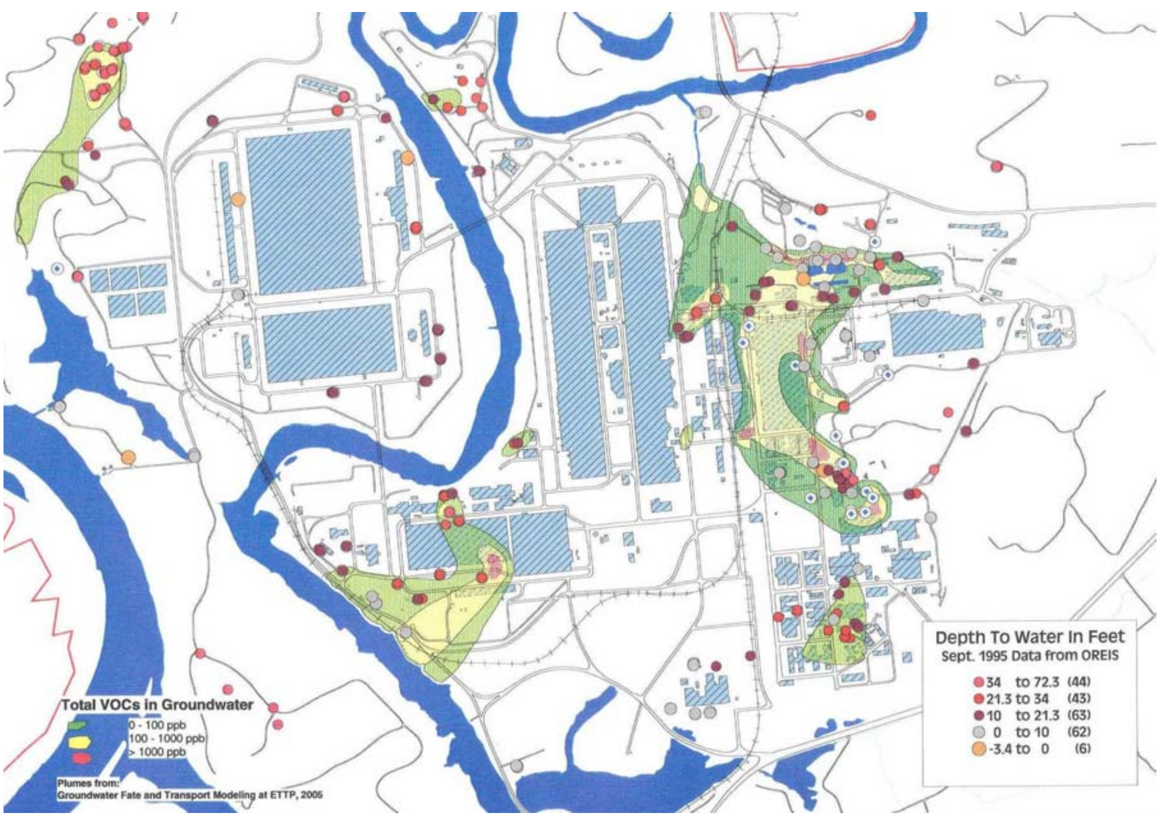


Figure 2. ETTP Groundwater Plumes (September 1995)



Conclusion

The results of these inspections revealed that the three reservation systems provide water that meets State regulatory levels. The distribution system at Y-12 does have some deficiencies in their Cross Connection Control Program, as noted in the sanitary survey.

References

Clesceri, L.S., A.E. Greenberg, and A.D. Eaton, editors. 1998. *Standard Methods for the Examination of Water and Wastewater*. 20th edition. American Public Health Association, American Water Works Association, and Water Environment Federation Washington, DC.

Tennessee Department of Environment and Conservation. *Regulations for Public Water Systems and Drinking Water Quality (Chapter 1200-5-1).* Tennessee Department of Environment and Conservation, Division of Water Supply. Nashville, Tennessee.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee*. Oak Ridge, Tennessee.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

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CHAPTER 3 DRINKING WATER

Implementation of EPA's RadNet (formerly the Environmental Radiation Ambient Monitoring System) Drinking Water Program (RMO)

Principal Authors: Howard Crabtree, Natalie Pheasant

Abstract

Now called RadNet, the Environmental Radiation Ambient Monitoring System was developed by the U.S. Environmental Protection Agency (EPA) to monitor potential pathways for significant population exposures from routine and/or accidental releases of radioactivity from major sources in the United States (U.S. EPA, 1988). This program provides for radiochemical analysis of finished water at five public water supplies located near and on the Oak Ridge Reservation. In this effort, quarterly samples are taken by personnel from the Tennessee Department of Environment and Conservation to be analyzed at the EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama. Although data from the program indicate tritium, gross beta, and strontium-90 results are higher for the Gallaher Water Treatment Plant than the four other systems monitored in the program, the results received from EPA to date have all been well below regulatory criteria.

Introduction

Radioactive contaminants released on the Oak Ridge Reservation (ORR) enter local streams and are transported to the Clinch River. While monitoring of these streams, the river, and local water treatment facilities has indicated that concentrations of radioactive pollutants are below regulatory standards, there has remained a concern that area public water supplies could be impacted by ORR pollutants. In 1996, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the division) began participation in the Environmental Protection Agency's (EPA) Environmental Radiation Ambient Monitoring System (ERAMS), which is now called RadNet. This program provides radiological monitoring of finished water at public water supplies near nuclear facilities throughout the United States. The RadNet/ERAMS program was designed to:

1. Monitor pathways for significant population exposure from routine and/or accidental releases of radioactivity;
2. Provide data indicating additional sampling needs or other actions required to ensure public health and environmental quality;
3. Serve as a reference for data comparisons (U.S. EPA, 1988).

The RadNet program also provides a mechanism to evaluate the impact of DOE activities on area water systems and validate DOE monitoring in accordance with the *Tennessee Oversight Agreement* (TDEC, 2001).

Methods and Materials

In the Oak Ridge RadNet Program, EPA provides radiochemical analysis of finished drinking water samples taken quarterly by division staff at five public water supplies located on and in the vicinity of the ORR. The samples are collected using procedures and supplies prescribed in *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (U.S. EPA, 1988). RadNet/ERAMS analytical frequencies and parameters are provided in Table 1.

Table 1: RadNet/ERAMS Analysis for Drinking Water

ANALYSIS	FREQUENCY
Tritium	Quarterly
Gamma Scan	Annually on composite samples
Gross Alpha	Annually on composite samples
Gross Beta	Annually on composite samples
Iodine-131	Annually on one individual sample/sampling site
Radium-226	Annually on samples with gross alpha >2 pCi/L
Radium-228	On samples with Radium-226 between 3-5 pCi/L
Strontium-90	Annually on composite samples
Plutonium-238, Plutonium-239, Plutonium-240	Annually on samples with gross alpha >2 pCi/L
Uranium-234, Uranium-235, Uranium-238	Annually on samples with gross alpha >2 pCi/L

The five Oak Ridge area monitoring locations are: Kingston Water Treatment Plant, Gallaher (K-25) Water Treatment Plant, West Knox Utility, City of Oak Ridge Water Treatment Facility (formerly DOE Water Treatment Plant at Y-12), and Anderson County Utility District. Figure 1 depicts the approximate locations of raw water intakes associated with these facilities.

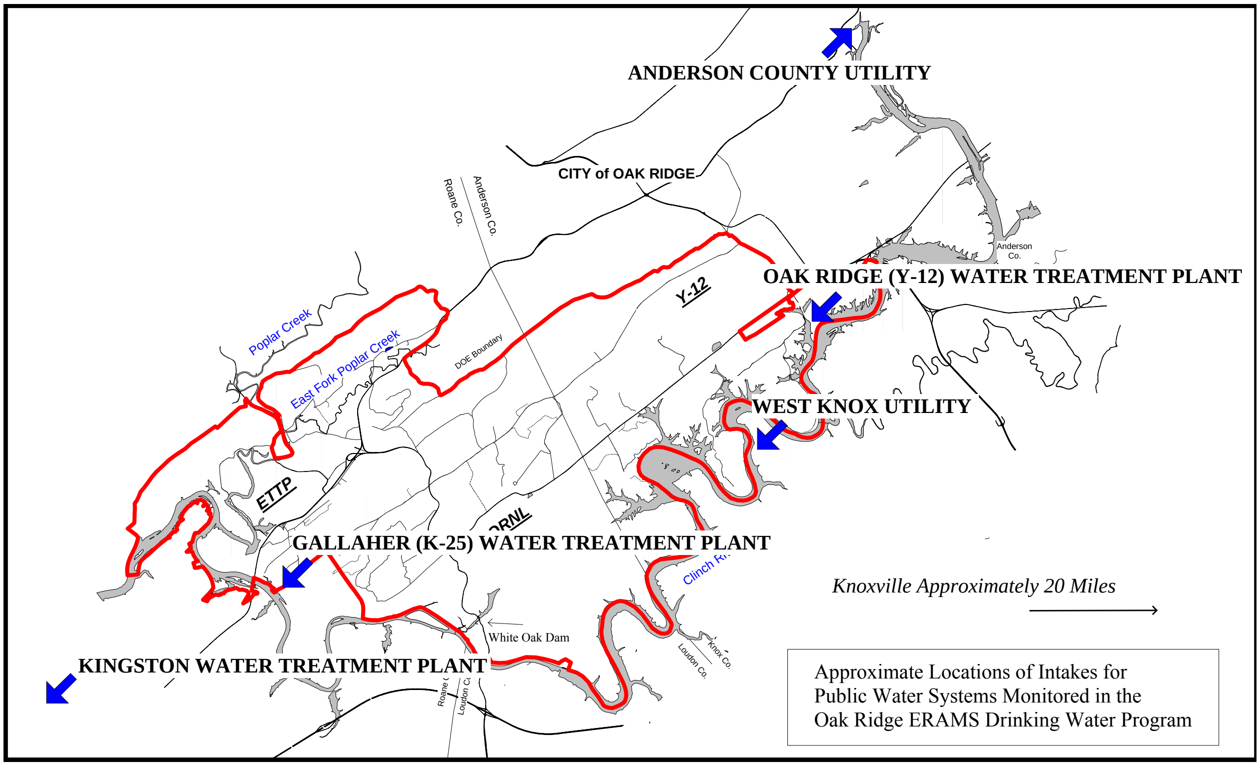

Figure 1: Approximate Locations of the Intakes for Public Water Systems Monitored in Association with EPA's RadNet/ERAMS Drinking Water Program

Results and Discussion

A large proportion of the radioactive contaminants that are transported off the ORR in surface water enter the Clinch River by way of White Oak Creek, which drains the Oak Ridge National Laboratory complex and associated waste disposal areas. When contaminants carried by White Oak Creek and other ORR streams enter the Clinch, their concentrations are significantly lowered by the dilution provided by the waters of the river. With exceptions, contaminant levels are further reduced in finished drinking water by conventional water treatment practices used by area utilities. Consequently, the levels of radioactive contaminants measured in the Clinch and at area water supplies are far below the concentrations measured in White Oak Creek and some of the other streams on the ORR.

Since the Gallaher Water Treatment Plant is the closest water supply downstream of White Oak Creek (approximately 6.5 River Miles), this facility would be expected to exhibit the highest concentrations of radioactive contaminants of the five utilities monitored in the program. Conversely, the Anderson County Facility (located upstream of the reservation) would be expected to be the least vulnerable to ORR pollutants. Based on the data collected since the Oak Ridge ERAMS Program began in July 1996, the above appears to be the case. Gross beta, strontium-90, and tritium have all been reported at higher levels in samples taken from the Gallaher Water Treatment Plant than at the other facilities monitored in the program. However, the results for the Gallaher Facility, as well as the other sites, have all remained well below applicable drinking water standards. A brief summary of the results received since the Oak Ridge program began follows.

Gross alpha, gross beta, and strontium-90 analysis has been performed annually on a composite of the quarterly samples taken from each facility starting in 1997.

- Gross alpha results have all been below 2.0 pCi/L, compared to a drinking water standard of 15 pCi/L.
- The highest gross beta results for the annual composite analysis was reported for the Gallaher Facility, which averaged 3.17 pCi/L with a maximum concentration of 3.86 pCi/L. The drinking water standard for beta emitters depends on the specific radionuclides present, but radionuclide specific analysis is generally not required at gross beta levels below 50 pCi/L.
- Of the thirty-nine yearly composite samples analyzed for strontium-90 (a beta emitter) since 1997, the only results reported above detection limits were for samples taken at the Gallaher Facility. These results indicate four of the eight Gallaher samples analyzed had low, but detectable, amounts of the radionuclide. The average result was 0.50 pCi/L and the data ranged from undetected to 0.99 pCi/L. The drinking water standard for strontium-90 is 8 pCi/L.

Analysis for iodine-131 was performed each year since 1996 on one sample from each facility. The radionuclide was only reported as detected in one of the samples analyzed. This result, 0.3 pCi/L, was from a sample taken upstream of the reservation, making the validity of the measurement suspect. The standard for iodine-131 is 3.0 pCi/L.

NAREL performs tritium analysis on each of the quarterly samples taken at the facilities in the program. Tritium is not readily removed by conventional treatment processes and is one of the most prevalent contaminants discharged by White Oak Creek into the Clinch River. Of the 186 tritium results reported for the five Oak Ridge Treatment Plants, only 24 were above detection limits. From the sample results above detection limits, 19 were from samples taken at the Gallaher Facility and 5 were reported for the Kingston Facility, further downstream. The results for tritium at the Gallaher Facility ranged from undetected to 1000 pCi/L and average 285 pCi/L. The drinking water standard is 20,000 pCi/L.

The results received from RadNet for 2005 (tritium and iodine-131) are similar to those received in past years. All iodine-131 results were below detection limits. Three results for tritium were above detection limits: one for the Kingston Water Treatment Facility (135 pCi/L) and two for the Gallaher Facility (130 pCi/L and 293 pCi/L). The average 2005 tritium results for each facility are provided in Figure 2. It should be noted, the instruments used in radiochemical analysis produce a slight reading due to the electronics associated with the equipment. This "instrument background" is determined prior to analysis and subtracted from the results. When the concentrations are low, it is not unusual for this to result in negative values, as can be seen in Figure 2.

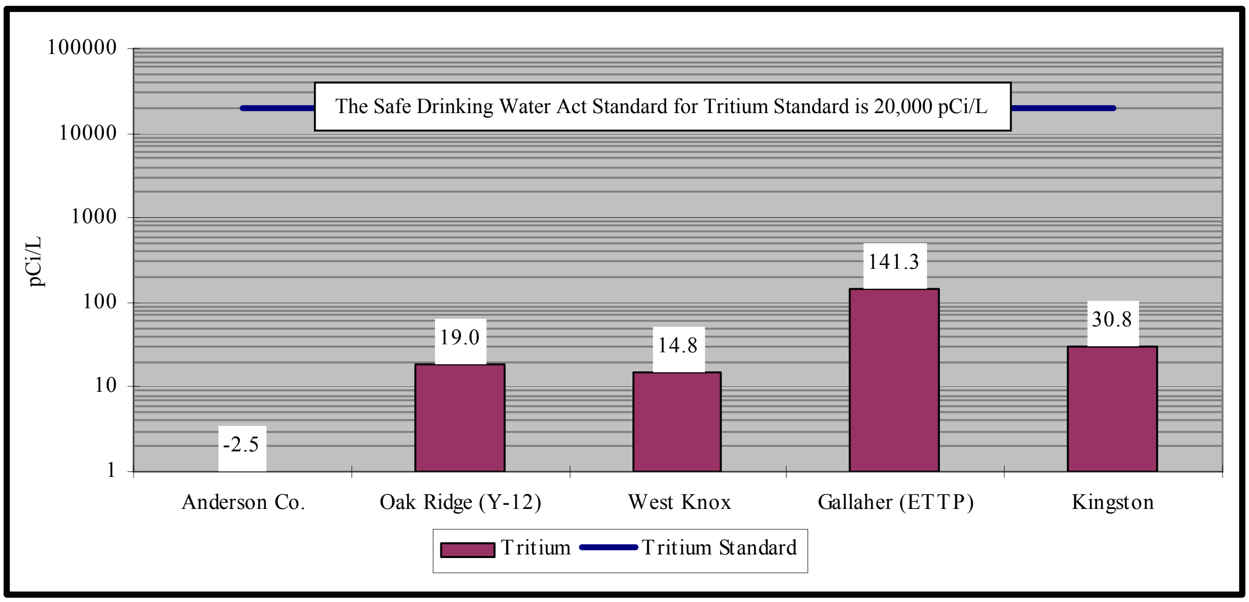

Figure 2: 2005 Average Tritium Results for Samples of Finished Drinking Water Taken at Oak Ridge Area Water Treatment Facilities in Association with EPA's RadNet/ERAMS Program

Conclusion

Radioactive contaminants migrate from the ORR to the Clinch River, which serves as a raw water source for area public drinking water supplies. The impact of these contaminants is diminished by the dilution provided by waters of the Clinch. Contaminant concentrations are further reduced in finished drinking water by conventional water treatment practices employed by area utilities. RadNet/ERAMS results over the last nine years have all been well below drinking water criteria. While below drinking water standards, gross beta, strontium-90, and tritium have all been reported at higher levels in samples taken from the Gallaher Water Treatment Plant than the other facilities monitored in the program. The Gallaher plant is the closest facility downstream of White Oak Creek, the major pathway for radiological pollutants entering the Clinch from the ORR.

References

Tennessee Department of Environment and Conservation, 2004. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division Environmental Monitoring Plan January through December 2005.* Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee.* Oak Ridge, Tennessee.

Thomasson, David, 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

U.S. Environmental Protection Agency (EPA), 1988. *Environmental Radiation Ambient Monitoring System (ERAMS) Manual.* EPA 520/5-84-007, 008, 009.

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CHAPTER 4 <u>GROUNDWATER MONITORING</u>

Oak Ridge Reservation and Vicinity Independent Sampling Report

Principal Authors: John E. Sebastian, Donald F. Gilmore and Clyde Edward Worthington

<u>Abstract</u>

Description of program – Scope of Monitoring

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducts independent groundwater sampling at springs, wells, and integrated surface sampling sites on or near the Oak Ridge Reservation. In calendar year 2005 groundwater-sampling projects included fifty-seven (57) springs/seeps, and wells, and two (2) surface water sites, for a total of fifty-nine (59) sites. Eight of these sampling sites were not sampled in 2005, two of those sites were flooded, and the six sites, which had been set aside for exit pathway locations expected to be located during reconnaissance 2006 within Melton Valley, were not found. The groundwater section successfully conducted sampling on a total of fifty-one (51) sites in 2005.

Exit pathway springs in the peripheral areas of the Oak Ridge Reservation are monitored for determination of the quality and effectiveness of the Department of Energy's (DOE) monitoring and surveillance programs. Domestic water wells are sampled to gauge any potential impact from DOE activities past and present to the groundwater resource in surrounding area. Samples are analyzed for radiochemicals, organic solvents, metals, inorganics, and nutrients. Parameters for analysis are chosen on a case by case basis dependent on expected and potential contaminants known or suspected contaminants at the sites being monitored.

2005 saw a significant expansion in the number of sites sampled and the scope of activities conducted by the groundwater section. Significant findings in 2005 include the monitoring of two springs offsite of ETTP showing volatile organic solvents. One spring located near ETTP and one residential well located across the Clinch River near White Oak Creek have shown tritium above expected levels though well below any concentration that would be expected to affect health or well being. It should be noted that the tritium concentrations each represent one and only one "hit" each.

Contra-wise, the offsite volatile plume from the Y-12 plant beneath Union Valley appears to have been to some extent mitigated by the pump and treat program initiated in 1998 – 1999 as the division's monitoring spring near Scarboro Road (Cattail Spring did not show volatiles during 2005.) Bootlegger Spring, which appears to represent the terminus of Y-12's Chestnut Ridge Security Pit plume however reasserted itself from 2004 with the reestablishment of a more normal hydrologic (decreased precipitation) environment in 2005.

Programmatic changes have centered on a significant increase in the number of locations being monitored, in particular the Offsite Program has essentially been reconstituted from 2004. Of specific interest in the division's offsite groundwater monitoring program has been the addition of Rose Bailey Spring located near Kingston approximately seven (7) miles southwest of the ETTP Site.

Rose Bailey is a significant spring and potentially represents a regional discharge of the carbonate units in the region. Its addition to division groundwater sampling represents the finding and filling of an important gap in offsite monitoring.

While overall significant inadequacies remain in the division's groundwater monitoring program the scope and integration of coverage has vastly increased in 2005 compared to 2006.

As an important addendum to this report is the discovery by division personnel that the protective gloves utilized in collecting environmental samples has been responsible for false positives for the volatile organic solvent carbon disulfide. A separate report on this investigation appears in the appendix.

Introduction

This chapter provides a status/review of the division's Environmental Monitoring & Compliance Program's Groundwater Section's findings. The Groundwater Section' staff sampled forty-nine (49) exit pathway springs and two (2) surface water sources (Figure 1, Table 1). These findings are based on sampling performed during calendar year 2005 (CY2005).

The Tennessee Oversight Agreement (TOA) with the Department of Energy (DOE) specifies the State to prepare a report of sampling results. Also the TOA mentions the reporting of *findings* based on the State's analytical results. With respect to the TOA's requirements and the following definitions, this chapter attempts to integrate results and findings as an independent comprehensive groundwater monitoring report.

- To monitor is to measure (gauge, calculate, determine, assess, quantify, evaluate, appraise, etc.) some aspect of groundwater;
- To sample is to extract some portion of a larger system of groundwater for testing.

The State is not inherently responsible for the groundwater monitoring of the Oak Ridge Reservation (ORR), rather it is DOE's responsibility to "monitor and surveil" groundwater contamination on the ORR and its environs. It is however the State's duty to provide independent oversight of the DOE groundwater monitoring program. The State is not limited in this duty and "independent monitoring," "supplemental monitoring" and other specific actions have proved to be the most effective means of addressing concerns over and inadequacies observed in DOE's monitoring programs. At times the State's performance of this function has lead to quantitative and qualitative improvements in DOE's monitoring and surveillance of contaminated groundwater on the ORR. A defensible argument can be made that this independent driver function of State monitoring of the ORR and environs groundwater is and has been a most valuable even indispensable part of maintaining the division's mission which is to protect the environment and people of Tennessee.

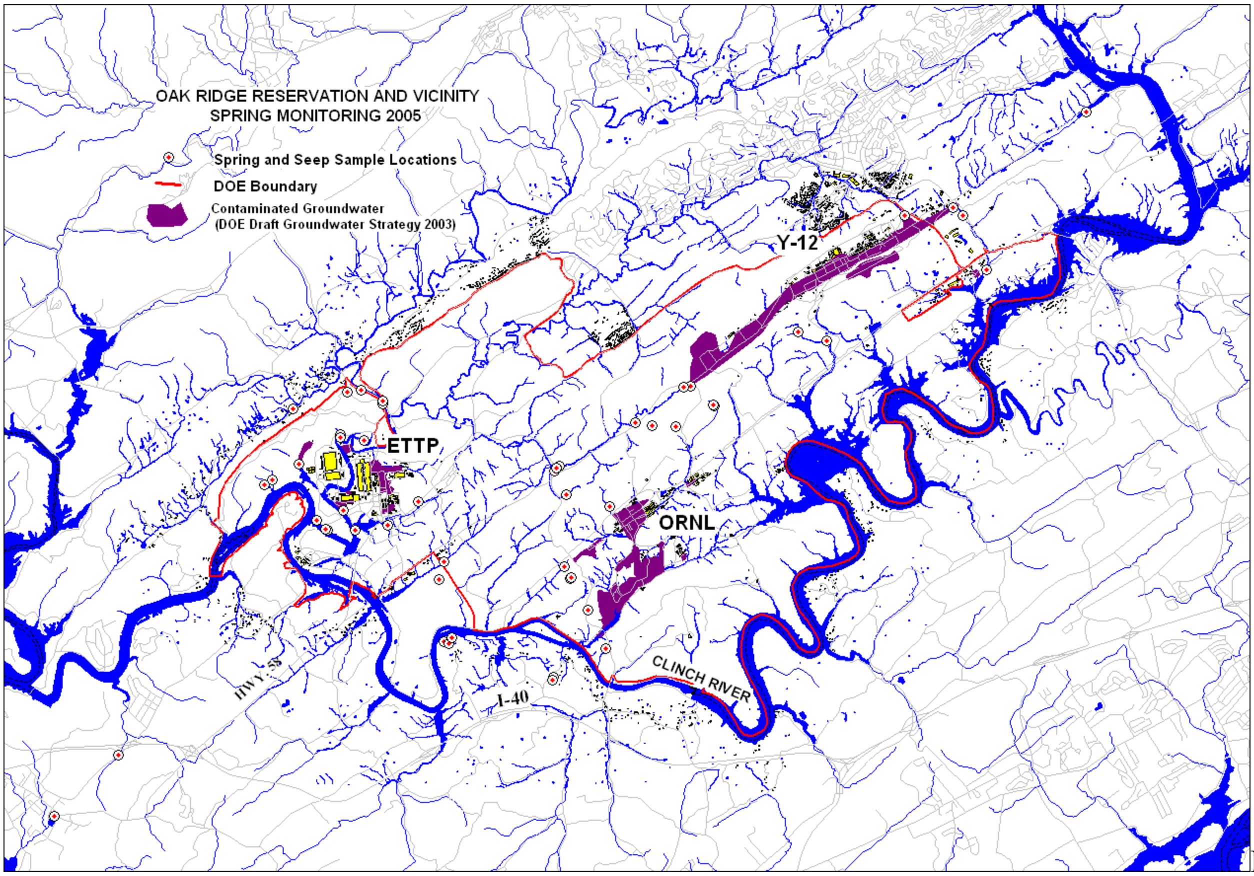

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Figure 1. Oak Ridge Reservation and Vicinity Spring Monitoring 2005 Locations

Table 1: Sampling Locations

Site	Station
ETTP (K-25)	Doug's Drip Sp.
	Z-boil Sp.
	Syncline Sp.
	USGS 21002 Sp.
	USGS 8-900 Sp.
	Lila's Leak Sp.
	Tree Root Sp.
	Fenceline Sp.
	JA Jones Sp.
ORNL (X-10)	Burns Cemetery Sp.
	Sycamore Sp.
	Gerry Sp.
	Crooked Tree Sp.
	Raccoon Creek Sp.
	Firing Range Sp.
	Merak Sp.
	Rifle Range Sp.

Table 1: Sampling Locations (cont'd)

Site	Station
ORNL (X-10) cont.	Parcel 10 Sp.
	Powerline Sp.
	Ish Creek Weir
	SNS-1 Sp.
	SNS-3 Sp.
	SNS-4 Sp.
	SNS-6 Sp.
Y-12	Bootlegger Sp..
	Cattail Sp.
	Cabin Sp.
	Cephus Sp.
	SS-5Sp.
	SS-6 Sp.
	SS-7 Sp.
	SS-8 Sp.
	MVMR/Mossy Rock Sp.
	New Weir
	West Railroad Sp.
	Bear Creek Km 4.78
OFFSITE	RWA-22
	RWA-29
	RWA-56
	RWA-65
	RWA-74
	Regina Loves Bobby Sp.
	Rose Bailey Sp.
	Love Sp.
	Dead Horse Sp.
EMWMF	Delegated to RMO program

Exit Pathway Monitoring

Effective monitoring of contaminants being transported by groundwater is largely a process of identifying and sampling the pathways by which the groundwater leaves the contaminated areas. Thus a significant portion of the division's groundwater sampling has been directed toward identifying and monitoring exit pathways on the ORR.

Given the nature of groundwater flow on the ORR, very effective monitoring may be conducted by sampling springs and seeps on and around the reservation. Springs and seeps represent convergent points where groundwaters emerge on the ORR and often represent the interface between contaminated groundwater and surface water affected by that contamination.

The division has been very effective in discovering contaminated and previously unmonitored new springs and seeps, such discoveries have contributed greatly to the understanding of contaminant movement on the ORR and doubtless there are significant such discoveries remaining to be made. 2005 saw a significant increase in the amount of resources the division applied toward the reconnaissance of new groundwater monitoring points and as a result there was a concomitant increase in the scope of monitoring conducted. However resources are still inadequate relative to the Division's mission of conducting meaningful oversight of the environmental challenges represented by the legacy of 60 years of DOE nuclear and chemical activities in East Tennessee.

Monitoring Known Contaminated Groundwater

Significant areas of the ORR are underlain by contaminated groundwater and the DOE performs extensive sampling of monitoring wells within these areas. Review and comments on annual reports regarding this monitoring is a task performed by the division as part of its TOA responsibilities.

While DOE's monitoring programs are substantial with respect to the number of monitored wells and sites, there are questions as to the program(s) effectiveness. Partly this can be attributed to the challenge of monitoring in East Tennessee's complex hydrogeologic setting, the larger part can be attributed to well emplacement and sampling points having been established utilizing a groundwater model based of extremely questionable assumptions. DOE surveillance data does help to draw plume maps showing the nature and extent of contaminated groundwater; however, there is a tendency for such maps to consistently show best case scenarios and to assume plumes do not exist where there is no monitoring, even when logic and experience would indicate extensive contamination to exist in an area. ETTP is perhaps the best example as division groundwater sampling can show that contaminants reach far to the west, east and south of acknowledged plumes at his site. DOE plume maps often understate the extent of impacts to groundwater.

The aquifers and the so-called "aquitards" (All bedrock units underlying the ORR qualify as aquifers by definition even if some minority of bedrock aquifers are in fact very poor producers for domestic water.) in East Tennessee are vulnerable to contamination and plumes spread rapidly. This concern is echoed in DOE's position to control through deed restrictions or notices many areas of groundwater use in the environs about the ORR. For this and other reasons, contact with groundwater on the ORR should be avoided. It is inevitable that long term monitoring of groundwaters in and around the ORR will be necessary to protect the people and environment of East Tennessee from the legacy of DOE operations.

Methods and Materials

The State Environmental Laboratory conducts the analysis of the water samples for radionuclides, volatile organic compounds, selected metals, nutrients, and inorganic parameters. The division's spring sampling activities typically include the parameters found in Table 2.

Finding new springs: Springs are normally found by walking along creeks and valleys and found often emerging in streambeds. Specific vegetation such as watercress, willow and sycamore trees is a common indicator of groundwater resurgence i.e. springs. Careful use of temperature and specific conductivity measurements help delineate groundwater resurgences and even separate different resurgences occurring within the same spring. In the areas of contaminant plumes, orange staining caused by iron related bacteria breaking down organic compounds also helps identify locations to sample. Smells or odors that may be sweet or stringent may contribute to the ability of locating a spring. However, if odors are noticed steps must be taken to insure the health and safety of samplers and others by notifying appropriate health and safety personnel.

Table 2. Parameters			
Nutrient, Metal & General Inorganic Analysis	**Radiological Analysis**	**List of TCL* Volatiles**	**List of TAL ** Semivolatiles**
Metals	**Typically**	Acetone	Acenaphthene
Arsenic	Gross Alpha	Benzene	Acenaphthylene
Barium	Gross Beta	Bromodichloromethane	Anthracene
Beryllium	Gamma Emitters	Bromoform	Benzo(a)pyrene
Cadmium	Tritium	Bromomethane	Benzo(a)anthracene
Calcium		2-Butanone (MEK)	Benzo(b)fluoranthene
Chromium	If suspected then isotopes of:	Carbon Disulfide	Benzo(g,h,I)perylene
Cobalt	Strontium	Carbon Tetrachloride	Benzo(k)fluoranthene
Copper	Technetium	Vinyl Acetate	Benzoic acid
Iron	Uranium	Chlorobenzene	Benzyl alcohol
Lead	Radium	Chloroethane	Bis(2-chloroethoxy)methane
Magnesium		Chloroform	Bis(2-chloroethyl)ether
Manganese		Chloromethane	Bis(2-chloroisopropyl)ether
Mercury		Dibromochloromethane	Bis(2-ethylhexyl)phthalate
Nickel		1,1-Dichloroethane	4-bromophenylphenylether
Potassium		1,2-Dichloroethane	Butylbenzylphthalate
Selenium		1,1-Dichloroethene	4-chloroaniline
Sodium		Cis-1,2-Dichloroethene	4-chloro-3-methyl phenol
Thallium		Trans-1,2-Dichloroethene	2-chloronaphthalene
Vanadium		1,2-Dichloropropane	4-chlorophenylphenylether
Zinc		Cis-1,3-Dichloropropene	Chrysene
		Trans-1,3-Dichloropene	Di-n-butylphthalate
General Inorganics		Ethylbenzene	Di-n-octylphthalate
pH		Methylene Chloride	Dibenzo(a,h)anthracene
Specific Conductivity		4-Methyl-2-Pentatone (MIBK)	Dibenzofuran
Total Alkalinity		Styrene	3,3’-dichlorobenzidine
Boron		2-Hexanone	2,4-dichlorophenol
Total Residue		1,1,2,2-Tetrachloroethane	Diethylphthalate
Suspended Residue		Tetrachloroethene	2,4-dimethylphenol
Dissolved Residue		Toluene	Dimethylphthalate
Sulfate		1,1,1-Trichloroethane	4,6-dinitro-2-methylphenol
Chloride		1,1,2-Trichloroethane	2,4-dinitrophenol
		Trichloroethene	2,4-dinitrotoluene

Table 2. Parameters (cont'd)			
Nutrient, Metal & General Inorganic Analysis	**Radiological Analysis**	**List of TCL* Volatiles**	**List of TAL ** Semivolatiles**
Nutrients		Vinyl Chloride	2,6-dinitrotoluene
NO3&NO2 Nitrogen		o-Xylene	Fluoranthene
		m & p xylene	Fluorene
			Hexachlorobenzene
			Hexachlorobutadiene
			Hexachlorocyclopentadiene
			Hexachloroethane
			Indeno(1,2,3-cd)pyrene
			Isophorone
			2-methylnaphthalene
			2-methylphenol
			4-methylphenol
			N-nitosodiphenylamine
			N-nitroso-n-dipropylamine
			Napthalene
			2-nitroaniline
			3-nitroaniline
			4-nitroaniline
			Nitrobenzene
			2-nitrophenol
			4-nitrophenol
			Pentachlorophenol
			Phenanthrene
			Phenol
			Pyrene
			1,2,4-trichlorobenzene
			2,4,5-trichlorphenol
			2,4,6-trichlorphenol
		*TCL (Target Compound List)	**TAL (Target Analyte List)

Field sampling: A sampling team locates the spring and collects the prescribed number of samples. The personnel wear disposable vinyl gloves while collecting samples. Sample labels (tags) and analysis request/chain of custody forms are completed. Samples are transported in coolers to the division's office for temporary storage, or may be taken directly to the Knoxville Basin Laboratory. Duplicate samples, trip blanks, and field blanks are taken as directed by the sampling plan.

Data Storage: Analytical results are stored in regular files in the DOE-O office, and the results are entered in a computer database. Eventually this data will be placed onto DOE's Oak Ridge Environmental Information System (ORIES) database. Copies of the lab analyses are periodically provided to DOE upon request.

Analysis: Data generated is analyzed as received and integrated into the sampling program. Both sampling and analysis are dynamic in that results can and do modify the locations and frequencies of sampling.

Results and Discussion

Groundwater General

Groundwater is the primary and initial mode of contaminant migration within ORR. To a great extent surface water contamination on the ORR begins as contaminated groundwater - from various disposal trenches, land-farms, and areas where contaminants were apparently simply spilled - emerges either in springs and seeps or as direct recharge into streambeds. Understanding the nature and movement of groundwater within the ORR is to understand the initial movement of contaminants from the ORR.

Geology on the ORR consists of Ordovician clastic and carbonate units thrust faulted into place with a resulting strike that is dominantly toward the Northeast - the bedding of these rocks predominantly dips towards the southeast at angles between twenty and forty-five degrees. The geologic structure controls the movement of groundwater with the along strike component being the predominant and cross strike irregularities being important within particular rock units. To this date sampling has not shown contaminants to have moved off the reservation via groundwater flow by crossing the regional northeasterly strike of the inclined bedrock, however contaminants in groundwater can be shown to have moved along the regional strike and past the reservation boundaries in several locations.

Groundwater movement within the ORR is thus demonstrably dominated by flow along remnant structures within the regolith above the bedrock and turbulent rapid flow in the bedrock along dissolution enhanced fractures in the karst units and along fractures within the clastic rock.

It has been doctrine that the Clinch River, which surrounds the west and south sides of the Oak Ridge Reservation, forms a hydrogeologic barrier to the movement of contaminated groundwater off the Oak Ridge Reservation. While the Clinch River does appear to be a barrier for contaminant transport it is not at all clear that it is an absolute barrier. While springs can be located that issue along the bank of the Clinch in support of the contention that the river is a hydrogeologic barrier, 2005 reconnaissance in low water stages of the TVA Watts Barr impoundment did not locate a significant number of springs and seeps of sufficient volume to completely support the belief that the Clinch is a totally effective hydrologic barrier.

Datum suggesting that the Clinch may not act as an impenetrable barrier for contaminant migration by groundwater does exist, it has been recognized that cavities below the base of the river are commonly encountered when bedrock wells emplaced in the vicinity penetrate to elevations beneath the bottom of the Clinch River. The actual base flow elevation of the region’s groundwater is not known, so a potential exists for contaminant migration beneath the Clinch River.

The ORR area is underlain by karst and fractured clastic aquifers. Particularly in the areas underlain by karst aquifers conduits may exist that have base levels below the Clinch River. There is a specific concern in the vicinity of the Hydrofracture underground waste injection projects that large pressures exerted during waste disposal potentially could also have had the force to underflow the Clinch River. Thus a critical location where monitoring needs to take place both on and off DOE property are areas that may potentially be affected by the Hydrofracture injections that took place at Oak Ridge National Lab (ORNL or X-10).

Also of concern for offsite contaminant transport are the Banks of the Clinch River and Poplar Creek in and about the ETTP area. Contaminated seeps and springs have been identified on TVA property, and will be discussed in detail in the ETTP Section of this report.

Significant areas to the east and north of the ORR are not however bounded by the implied hydrologic barrier represented by the Clinch River, indeed it has been determined that plumes do cross the ORR boundary and impact groundwaters offsite and along strike. In particular plumes have been demonstrated to exist in Union Valley east of the Y-12 plant, and within Chestnut Ridge East of the Security Pits. Significantly both these plumes are within well-developed dissolution enhanced turbulent conduit aquifers hosted by soluble rock karst aquifers namely the Maynardville Limestone and the dolomite of the Knox Group.

More problematic is the area north of K-25 bounded by dolomites of the Ordovician Knox Group. While the Knox Dolomites form Black Oak Ridge and any direct contaminant migration from the historic K-25 Site (ETTP) would not be expected through the ridge itself the question remains as to the potential that some waste may have been disposed on the ridge itself and may affect groundwaters to the north of ETTP.

Sampling results from calendar year 2005 showed significant changes from 2004 sampling. Improvements were noted in Union Valley as the plume seemed to respond to the installation of a pump and treat system. The plume originating in the Security Pits on Chestnut Ridge however reasserted itself as rainfall returned in 2005 to more normal values. Gross alpha levels in springs of Bear Creek Valley fell after completion of remediation projects in the Valley; however overall concentrations of gross alpha in creek waters seemed to remain the same suggesting that while input to groundwater has diminished contaminant flux out of the valley has yet to show improvement. ETTP showed two offsite problem areas as organic solvent plumes were tracked by the division offsite on both the east and the west sides of the plant area, more problematic is a single tritium result offsite in Regina loves Bobby Spring located on the northern scarp of Black Oak Ridge.

Perhaps of greatest significance to the division’s groundwater mission is the re-establishment of the offsite residential well monitoring program. The division now routinely monitors thirteen (13) residential wells and offsite springs most of which are located across the Clinch River and to the southwest of ETTP, ORNL, and Melton Valley. Of particular note is the addition of Rose Bailey Spring to the offsite monitoring program. Rose Bailey, a large spring located approximately 7 miles southwest of the ETTP, appears to represent a groundwater emergence fro the region to the southwest of ETTP. Monitoring at this point will provide assurance to the presence or absence of contaminants originating at ETTP within a significant area near the plant.

Exit Pathway Springs General

In general terms, DOE compliance monitoring showed heavily contaminated groundwater near historic disposals, spills and releases on the ORR. As DOE performs extensive monitoring in and near the highly contaminated areas on the ORR and as such monitoring is resource intensive the division’s groundwater program has concentrated on the identification and monitoring of potential and actual exit pathways on and off the reservation.

This program has and continues to add significant value to efforts to monitor groundwater impacts of current and legacy DOE operations on and off the ORR. While 2005 saw significant improvements in both the quantity and quality of groundwater monitoring achieved by the division, proper coverage of the complex geology and contaminants existing on and under the Oak Ridge Reservation is by no means complete and must still be considered “lacking.”

Groundwater remains the major modality by which contaminants are initially transported from disposal sites on the ORR. Despite operating with limited resources the division's groundwater monitoring program has identified several new points of concern, continued to monitor known exit pathway points and to have identified and sampled what appears to be a regional groundwater emergence southwest of the ETTP (Rose Bailey Spring).

However, there are numerous deficiencies in the division's exit pathway groundwater monitoring efforts. In general a number of significantly contaminated areas are inadequately monitored or even currently not monitored. Additionally, planned groundwater basin delineation via dye tracing was not accomplished as intended in the 2005 Groundwater Monitoring Plan. Nor was access to a number of important exit pathway monitoring wells controlled by DOE contractors obtained in calendar year 2005.

As in 2004 several important exit pathway springs near Y-12 and East Tennessee Technology Park (ETTP or K-25) remained off limits due to the lack of proper air monitoring safety equipment and past health and safety issues associated with smells and vapors emanating from said springs.

The concern in 2003 and 2004 regarding locations becoming inundated under impoundments created by beaver dams continued as a problem into and through 2005. An efficient method to remove beaver ponds to allow sampling has yet to be achieved.

Exit Pathway Springs ETTP (K-25)

Division groundwater monitoring in and around ETTP continued to show contamination reaching several offsite areas. In particular TDEC sampling showed volatile organic solvents at Spring 10-895 north of the main plant area, at PCO Seep on the bank of the Clinch River west of the plant and spring 21-002 seemed to show increasing concentrations of contaminants.

Spring 10-895 located just offsite along the bank of Poplar Creek near Blair Road showed trichloroethylene (TCE) at levels just above the MCLs. PCO seep located on the bank of the Clinch River on TVA controlled property showed levels as high as 26.5 ppb TCE (note PCO Seep was sampled early 2006 and is cited here to illustrate the offsite nature of contaminated groundwater in 2005). The source of the TCE in spring 10-895 is simply not known. Speculation bounds from the potential that spoil areas on Blackoak Ridge may have wastes disposed within to the possibility that karst conduit transport of volatile contaminants is occurring from the K-1070-A burial ground located along strike (2.2 km map west) or a completely unknown source such as spillage along the nearby railroad tracks may account for contaminants found in the 10-895 spring water.

Conversely plume and degradation models generated in 2005 by DOE contractors in the main plant area and from the K-1070-A Burial Ground consistently showed plumes either smaller than previously mapped or at decreasing concentrations in the case of Spring 21-002 (known to drain the K-1070 burial Ground).

Inevitably it must be accepted that the plumes known to exist within the main plant area are poorly delineated and given the offsite results obtained by the division's groundwater monitoring program certainly not contained.

Further while degradation models for the volatile plume at the K-1070 Burial Ground suggest that concentrations at Spring 21-002 should be decreasing division sampling suggest that concentrations of volatiles at the spring are increasing with TCE quarterly sampling results showing 7.1, 13, and 17.4 ppb of TCE (no sample was obtained for summer 2005). Initial 2006 results show a further increase.

Additionally some concern must be shown to preliminary division sampling results obtained from Regina loves Bobby Spring located on the scarp of Blackoak Ridge map north and across the ridge from the ETTP main plant area. The last sample obtained from this location in 2006 showed what appears to be the presence of very low levels of tritium in the spring's waters. While the results are very low and pose no know threat to health from consumption of the water the potential that any contamination has managed to be transported from the historic K-25 Site into groundwaters occurring on the opposite side of Black Oak Ridge is a cause for concern.

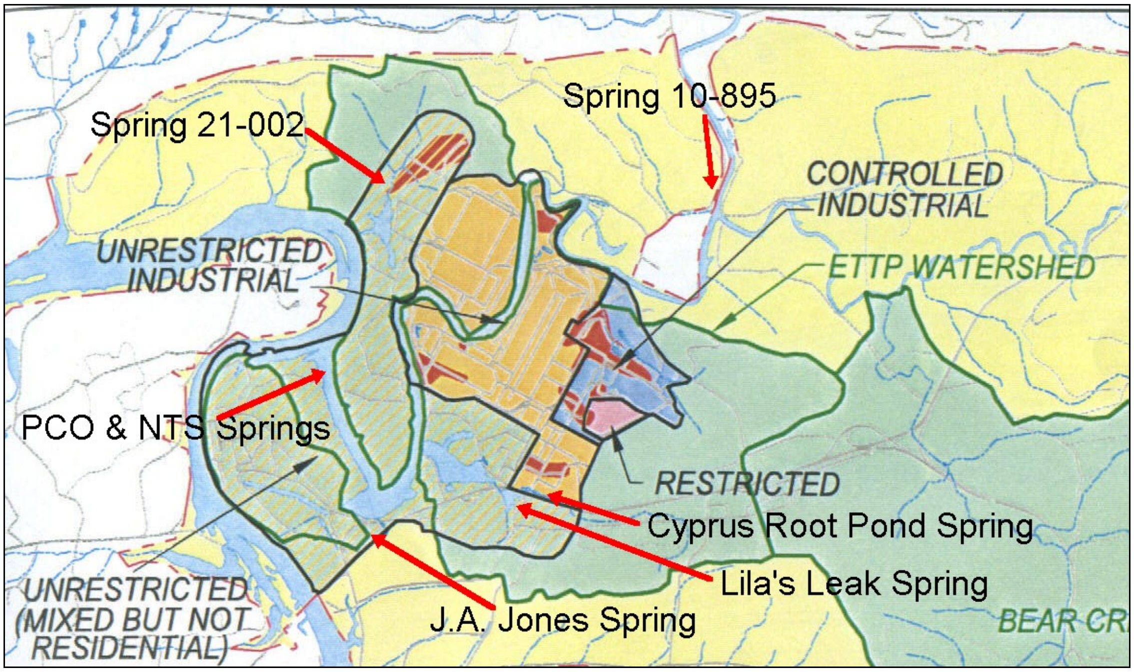

Figure 2. Map of K-25 area showing plumes as red or dark patches. Spring locations are not near mapped plumes except Spring 21-002. To achieve effective monitoring plumes will have to be better understood in relation to impacted springs

ETTP represents a major challenge in the effort to provide adequate groundwater monitoring, of the complex contaminants present – a mixture of radiochemicals, volatiles, semi-volatiles, and, metals, emplaced within a complex geology of folded and faulted dissolutionaly enhanced fractured carbonate rock, as well as a few fractured clastic rocks. Overlaying this a complex though most inoperative industrial site.

Complicating proper characterization is dearth of wells penetrating bedrock particularly wells that would cover the southern portions of the plant site. The tendency has been to use these inappropriately placed wells to attempt to model plumes.

The division has consistently maintained that modeling is inappropriate and not a replacement for physical monitoring, given the complexities of the ETTP Site and the mix of contaminants. Sampling results support the contention that the plumes at ETTP need to be monitored and mapped rather than modeled, that contaminated groundwater on the ETTP is not well characterized and not contained within the boundaries.

Exit Pathway Springs ORNL and Melton Valley

Division sampling of exit pathway springs for ORNL and Melton Valley was of limited extent in 2005. This was due to some extent to the limited resources available for the groundwater program and also to the dearth of expected sampling points.

Reconnaissance of areas underlain by the Maynardville Limestone in the western portions of Melton Valley failed to find the expected springs, further planned reconnaissance of the eastern portions of areas underlain by the Maynardville and areas to the east of the main campus did not occur as personnel resources were not available for these tasks in 2005.

The division did continue to sample Raccoon Creek Spring and in Raccoon Valley (map west of ORNL) and Crooked Tree Spring in Melton Valley (Figure 3). Both springs continued to show radiochemicals strontium 90 and tritium in approximately the same orders of frequency and magnitude as in 2006.

A significant portion of the division's offsite residential well monitoring program is based on historic contaminants such as the Hydrofracture located in Melton Valley and serve to some extent as exit pathway monitoring for ORNL or rather it is hoped they serve to show that no exit pathway exists to domestic wells located on the opposite side of the Clinch River from the ORR. These wells will be discussed in detail below in the section on residential wells.

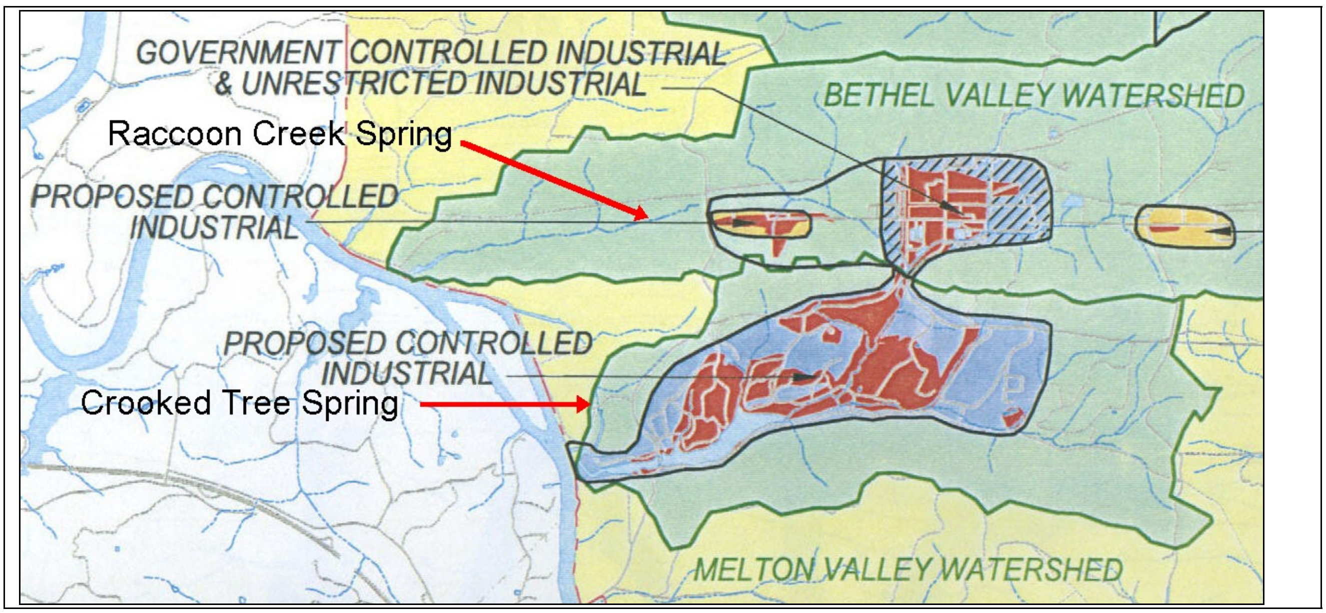

Figure 3. Oak Ridge National Laboratory (ORNL or X-10) Note plume pathways are not drawn to impacted springs.

Exit Pathway Springs Y-12

Exit pathway monitoring at Y-12 consists of four separate areas of interest (Figure 4).

1. The Union Valley plume originating at or about the site of the closed New Hope Pond and emanating eastward through the karst conduits of the Maynardville Limestone apparently have been reemerging at Cattail Spring, which has been and is a significant monitoring point for the division's program.

   Cattail Spring, which had intermittent showings of the organic solvent carbon tetrachloride during 2004, was notable by the absence of the contaminant in 2005. It is suggested that the pump and treat system established some years previously within the eastern portion of Y-12 has mitigated the extent of the organic solvent plume.

   While this apparent mitigation is commendable it suggests the need for further monitoring and access to wells in the area to judge the extent of plume retreat. Further, it opens up a serious question regarding a differing set of volatiles that is known to exist under a capped municipal landfill located toward the eastward of Cattail Spring in Union Valley (currently a driving range is located on the capped landfill) and suspected of impacting groundwater. Is there a potential for this pump and treat system to mobilize contaminants from this landfill?

   If resources are available, the division will attempt to perform sampling of various wells in the area to ascertain the extent of movement if any of both these plumes.

2. The Security Pits Plume, which originates on Chestnut Ridge and moves east to emerge at Bootlegger Spring on the UT Arboretum.

   Bootlegger Spring in the University of Tennessee Arboretum has shown through past sampling that organic solvents associated with the Security Pits disposal area on Chestnut Ridge near Y-12 flow through the dissolutioned conduit aquifers that are known to exist within the Ordovician aged Knox Dolomites that compose Chestnut Ridge and to exit at Bootlegger Spring within the UT Arboretum.

   Sampling during the two extremely wet years of 2004 and 2003 showed organic solvents only appearing during low flow conditions late in those years, whereas in previous years of sampling the spring showed consistent if low concentrations of organic solvents. 2006 showed a return to a more consistent output of Security Pits related organic solvent concentrations.

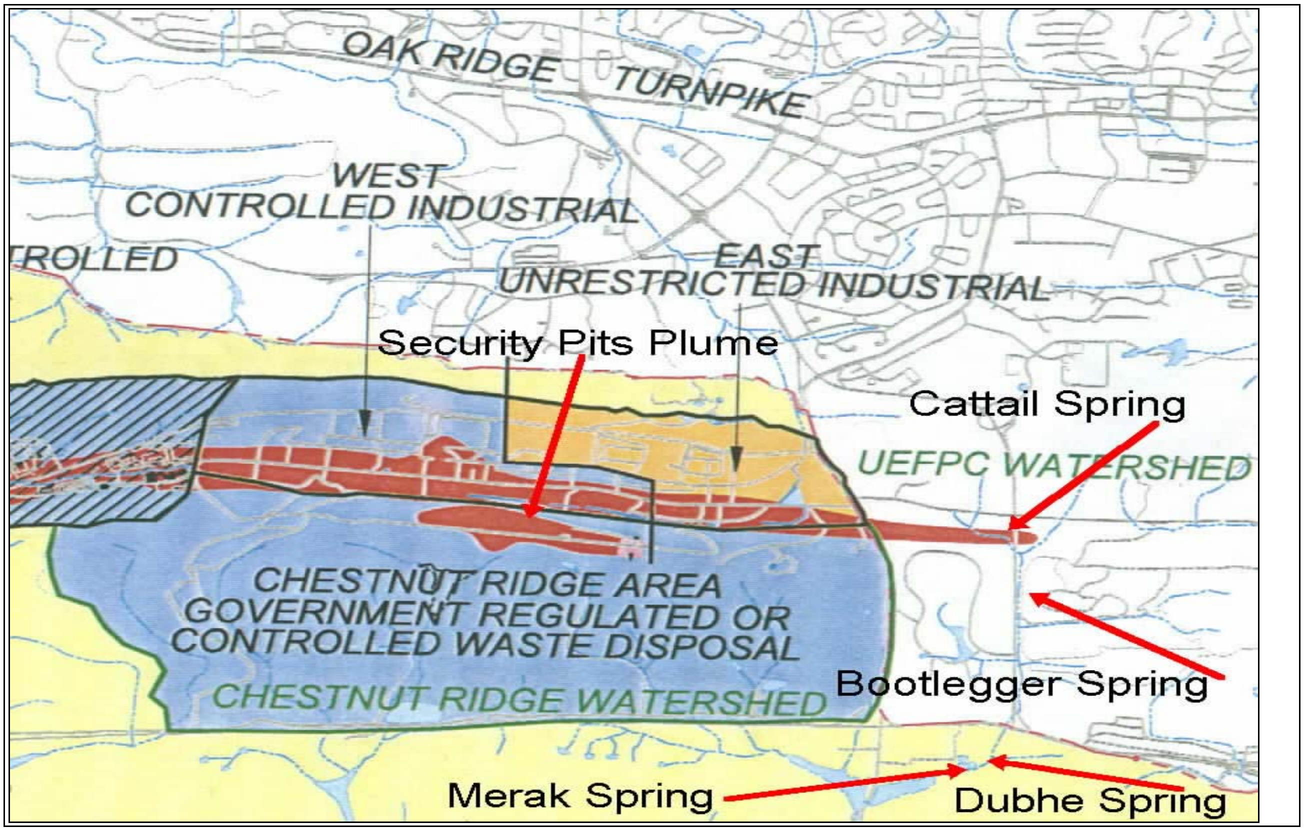

Figure 4. Portion of exit pathway monitoring at Y-12

3. Various small springs and seeps located down slope of the burial grounds that are located on the map south slope of Chestnut Ridge.

4. Springs and surface waters of Bear Creek west of the main plant area also located in the main on the well developed karst aquifer of the Maynardville Limestone.

   Exit pathway monitoring in Bear Creek consists of a number of a series of large springs located on the north-facing scarp of Chestnut Ridge and surface water locations in Bear Creek itself. Surface water sites are integrated into groundwater monitoring, as Bear Creek is a surface expression of the well-developed subsurface karst conduit drainage within the Maynardville Limestone Formation.

   It is an understatement to say that a number of significantly contaminated sites exist in Bear Creek. Unless removed, the valley contains essentially inexhaustible amounts of depleted uranium, organic solvents, and nitrous contaminants derived from nitric acid. These wastes were in general emplaced in unlined burials within the various fractured clastic units that underlie the majority of Bear Creek Valley with the exception of the strip immediately in front of and to the north of Chestnut Ridge, which is underlain by the previously mentioned Maynardville Limestone. Waste emplaced in these fractured clastic units tends to drain toward and into the previously mentioned surface subsurface karst system of Bear Creek within and on the Maynardville Limestone Formation.

2005 was the first complete year of sampling conducted from the finish of significant remedial projects within Bear Creek Valley most notable being the remediation of the Bone Yard Burn Yard (BYBY). The BYBY had been a significant source of gross alpha contamination seen in springs in Bear Creek Valley. With its closure 2005 has seen a decrease in gross alpha concentrations in the spring's waters.

However, no following reduction in concentrations have been seen in the surface water sites sampled by the division's groundwater program suggesting that the waste material has "found another modality" for entering the creek.

Complicating the monitoring of Bear Creek Valley has been the emplacement of the EMWMF more generally referred to as the Waste Cell. Intended to contain wastes from remediation projects across the ORR division monitoring personnel have considered site location, construction, and operation of the waste cell to be problematic.

5. The division samples a number of small springs located on the southern face of Chestnut Ridge and down slope of the DOE landfills located on the Ridge. As in previous years during 2006 these springs did not show contamination, nevertheless these sampling points represent a needful monitoring location showing that contamination within the landfills are not effecting these potential receptors.

Offsite Residential Well and Spring Monitoring

Division monitoring of offsite residential water sources (springs and wells) in 2005 represented a re-establishment of efforts to monitor potential impacts to groundwater used offsite as a source of drinking water. Criteria used for choosing residential wells and offsite springs to be included in the division's sampling and analysis program is dependent on the potential of DOE operations past or present to affect the groundwater that supplies the well or spring.

It should be noted that there are multiple pathways other than the direct migration of contaminants by groundwater movement that must be considered in any rational plan for the monitoring of offsite groundwater that is used or potentially might be utilized for consumption.

While the division's offsite program has concentrated on areas that have the potential of a direct effect on groundwater offsite - such as wells located directly across the Clinch River from Melton Valley and the Hydrofracture project which injected significant amounts of radiochemical waste beneath Melton Valley – and wells locate southwest of the ETTP – it is important to recognize that any well in the vicinity may be also impacted by releases ranging from air deposition, contaminated sediments being accessed by wells emplaced in alluvial material, to wells being drilled by contaminated equipment that may have been in use onsite.

Offsite wells and in some cases springs are also generally privately owned and the division is limited to requests for sampling or requesting permission to sample. It is generally the division's practice to sample any reasonable site upon request at least once.

Results obtained from offsite sampling in 2005 saw four contaminated springs Bootlegger, and Cattail (located in the UT arboretum, and Union Valley respectively and discussed in the section on Y-12) 10-895 and PCO Seep (located east and west of ETTP and discussed in the ETTP Section).

Another spring Regina loves Bobby (located to the north of ETTP and discussed in detail in the ETTP Section) showed a very small amount of tritium in fall quarter sampling. While the tritium result was not repeated in fourth quarter sampling of this spring the significance of any contaminant in an offsite spring has justified increasing eth sampling frequency to monthly until the question of tritium in this offsite spring is resolved. Speculation as to a possible explanation of this result varies from an air source related to TSCA incinerator operations, an unknown source of contamination buried on Blackoak Ridge to the inherent statistical potential associated with radiochemical analysis.

Residential well sampling also saw a tritium indication in RWA 74, the well water collected during October, showed tritium activity measured at 409 pCi/L with a calculated error of 188 pCi/L and a MDA (minimal detectable activity) of 307 pCi/L. While this result has not been replicated (domestic wells generally being sampled annually) the reported MDA and error suggests that tritium has been detected in this well. No other radiochemicals other than the generally expected daughter products of naturally occurring radon and uranium have been detected in samples obtained from this well.

It should be emphasized that the level of tritium detected is two orders of magnitude below the MCL of tritium activity - 20,000 pCi/L, and pose no recognized risk to human health. Emphasis should also be placed on other possible sources of tritium that may have affected this well – such as possible infiltration of rainwater containing tritium, the disposal of a tritium source in the area – or that this analysis may represent a statistical outlier.

It should also be noted that other domestic wells in the general vicinity of RWA-74 have not indicated tritium activity above the MDA as of the most recent sampling in calendar year 2005.

Nevertheless due to the wells proximity to Hydrofracture and Melton Valley the indicated presence of any known radiochemical contaminants associated with Hydrofracture in particular and Melton Valley in general is a cause of concern. Sampling frequency for RWA 74 has been increased in 2006 until this situation is also resolved.

A significant spring designated Rose Bailey Spring, which feeds the Rose Bailey Lake impoundment and is located approximately seven miles southwest of ETTP was sampled in 2005. Rose Bailey is significant as it is a large spring by East Tennessee standards observed to be producing as much as 150 gallons per minute (gpm) during the drought conditions that existed in September 2005. Rose Bailey Spring also lies along a geologic synclinal structure and within the carbonate Ordovician age Chickamauga Supergroup, giving ample reason to expect that Rose Bailey Spring represents a regional emergence of groundwater.

While no DOE related contamination could be identified in samples obtained from Rose Bailey or two other springs in the area (Love and Dead Horse Spring), Rose Bailey will remain a pivotal part of division offsite monitoring of groundwater due to its geologic setting and volume of water produced.

Conclusions

Effective monitoring and surveillance of groundwater plumes is the goal of the division's groundwater monitoring program. Given the seriousness, and amounts of waste emplaced within the complex hydrogeology of the ORR, effectiveness becomes the key aspect of any monitoring program. Current waste in the groundwater will remain for years, decades or even longer, the eventual maturation of plumes, effectiveness of remediation efforts, is problematic. Problematic also is the future dependence of East Tennessee on its groundwater resources. Therefore, the division in its oversight role has focused monitoring on measurable and mappable quantities, rather than conjectures of the fate and transport of contaminants based on faith in computer based models.

Definite progress has been made from calendar year 2004 in the division's goal of providing effective monitoring of the impact of past and present DOE activities on and off the Oak Ridge Reservation, of protecting the public and the environment of East Tennessee from the impact of the contamination legacies of the cold war. 2005 saw an increase in the number of sites samples, number of analyses made, and the comprehensiveness of division groundwater monitoring.

However, it should be noted that in some aspects the division's groundwater program represents the only monitoring of groundwater that is occurring or is intended to occur. An example of this is the offsite monitoring program where the division has "inherited" the responsibility of determining the impact, if any, of DOE related contaminants sources on or from the ORR. Another important area that appears to be falling more and more into the division's groundwater monitoring program is exit pathway monitoring. While monitoring in areas near buried contaminants will in most instances have to remain a province of the DOE and its main contractors.

Groundwater monitoring of the Oak Ridge Reservation is a target rich environment. The complexities and sheer quantities of the contaminants combined with the complex hydrogeologic subsurface environment create a monitoring problem for which the word challenging is an understatement. Current monitoring efforts must be yet described as falling far short of what is necessary to perform the division's mission of protecting the public and environment.

References

DOE, Office of Oversight, Environment, Safety and Health, October 2000. *Independent Investigation of the East Tennessee Technology Park.*

DOE/OR/01-2069 & D1. *Oak Ridge Reservation Groundwater Strategy.*

ORNL/TM-12074. *Status Report on the Geology of the Oak Ridge Reservation.*

Region IV EPA, May 1996, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.

Rubin, P. and Peter Lemiszki, 1992 (unpublished report for MMES/DOE) *Aspects of Oak Ridge Karst Hydrology and Geomorphology.*

TDEC DOE-O 1996. TDEC DOE-O *Standard Operating Procedures*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

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APPENDIX A

Groundwater Monitoring
Oak Ridge Reservation and Vicinity Independent Sampling Report

Investigative Report of Carbon Disulfide Contamination in Powder Free Latex Exam Gloves

Investigative Report of Carbon Disulfide Contamination in Powder Free Latex Exam Gloves

Principal Authors: Clyde E. Worthington, R.G., John E. Sebastian, P.G., Donald F. Gilmore, P.G., and Robert C. Benfield, P.G.

Abstract

Carbon disulfide contamination discovered in powder free latex exam gloves used for environmental groundwater sampling:

Tennessee Department of Environment and Conservation (TDEC) Division of Department of Energy Oversight (the division) is tasked with providing an oversight role in monitoring groundwater on the Oak Ridge Reservation. As part of fulfilling this obligation the division conducts independent sampling and analysis of groundwater in and around the Oak Ridge Reservation (ORR)

During summer and fall of 2005, division personnel in Oak Ridge, Tennessee received analytical results from routine sampling showing carbon disulfide in groundwater samples. These detections were in areas that had not been known to exhibit carbon disulfide contamination in the past and appeared to be randomly distributed between sampling events and locations, further carbon disulfide had not been a known or suspected contaminant within the division's sampling area, the ORR and its environs. Division personnel began to investigate and question potential factors that would have resulted in the carbon disulfide detections.

The factors considered were legitimate detections of carbon disulfide, cross contamination at the analytical laboratory during analysis, cross contamination of the storage area for sampling equipment, cross contamination from environmental aspects during sampling and transport to the laboratory, and cross contamination by the powder free latex gloves worn by personnel during sampling. Tests for each factor were developed and completed. These testing methods included communication with the analytical laboratory, a sample blank for the equipment storage area, sample blank for the transport of the sample, a sample blank for field sources, and an experiment with the powder free latex gloves in which samples of the glove were soaked in de-ionized water and then sent for analysis. Positive carbon disulfide results from the glove experiment indicated that the carbon disulfide was a product of cross contamination from the powder free latex exam gloves.

Introduction

Carbon disulfide is a volatile organic compound (VOC) with a chemical formula of CS_2. It is a known reproductive hazard and is known to disrupt the central nervous system. It is used as a solvent in many manufacturing processes. It is not known to be a contaminant at the Oak Ridge Reservation (ORR)

During the implementation of TDEC DOE-O's sampling and analysis plan for groundwater in 2005, personnel observed reported detections of carbon disulfide in analytical results. These detections were in areas that had not been known to exhibit carbon disulfide contamination in the past and appeared to be randomly distributed between sampling events and locations. Further carbon disulfide has not been a recognized contaminant within the Oak Ridge Reservation. Division personnel began to investigate and question potential factors that would have resulted in the carbon disulfide detections.

Results showing detections of carbon disulfide began after the analytical laboratory analyzing the samples changed from the state analytical lab to a subcontracted laboratory for VOC (volatile organic carbon) analysis. Division personnel determined (from personal contact with laboratory staff) that the subcontracted laboratory had a lower method detection limit (MDL), thus allowing the carbon disulfide to be detected. Suggesting that carbon disulfide may have been present within some prior samples at levels below the original laboratory's MDL.

TDEC DOE-O personnel determined what factors could contribute to the detections of carbon disulfide other than the difference in the two MDLs. The following factors were considered to be the potential factors for the reported carbon disulfide detections: legitimate detections of carbon disulfide, cross contamination at the analytical laboratory during analysis, cross contamination of the storage area for sampling equipment, cross contamination from environmental aspects during sampling and transport to the laboratory, and cross contamination by the powder free latex gloves worn by personnel during sampling.

Division personnel examined all potential factors in order to develop experiments or checks to validate the potential factors, so as to eliminate each factor that did not contribute to the carbon disulfide detections.

Methods and Materials

The methods of examination for each potential factor varied from communication with laboratory analysts to experimentation with the powder free latex gloves. Communication with the laboratory included verification that there were no indications of cross contamination in the handling of the sample by the laboratory. This was accomplished by a laboratory review of quality control/quality assurance (QC/QA) data routinely performed in the analysis of each sample to ensure the validity of the results.

Three blanks composed of deionized (DI) water were used to determine if cross contamination from the equipment storage area, from the transport of the sample, or from the field sources had occurred. To be consistent with sampling technique, the blank samples used the same type 40-milliliter (mL) glass vial containers preserved with hydrochloric acid (HCL). They were filled with DI water using the same procedure as would be used to collect a sample of groundwater.

An experiment was developed to examine the powder free latex gloves for their potential to contribute to cross contamination of the groundwater samples. The materials used for the experiment were powder free latex gloves, a decontaminated 1000 mL beaker, 40 mL glass vials preserved with HCL, and DI water. The beaker was decontaminated by washing the beaker using Alconox ® detergent, rinsing with tap water, and a final rinse with DI water.

The beaker was filled with DI water and a powder free latex glove was placed in the beaker. After twenty minutes, the glove was removed and a sample from the DI water in the beaker was collected using the same type 40 mL glass vials preserved with HCL and procedure as would be used to collect a groundwater sample.

The three blanks of deionized water and the samples exposed to the latex gloves were sealed and transported to the Knoxville State laboratory for trans-shipment to the subcontracting analytical laboratory under the same protocol as the original field samples, which had shown the carbon disulfide.

Results and Discussion

Communication with the laboratory did not reveal any abnormal findings in methodology by which the samples and/or the analysis had been handled. Suggesting that laboratory cross contamination was not a factor.

Analysis of the three blanks collected from the equipment storage area, from the transport of the sample, and from the field sources did not detect any carbon disulfide. Therefore, no cross contamination from these potential factors were indicated.

Analysis of the samples collected from the glove experiment detected carbon disulfide in varying concentrations dependent upon glove manufacturer. Table 1 displays the results for each glove and manufacturer tested. These results indicate cross contamination from the gloves was the most likely source of the carbon disulfide detections.

Table 1: Carbon Disulfide in Latex Gloves

Carbon Disulfide in Latex Gloves CAS Number = 75-15-0				
Manufacturer	**Date Sampled**	**Results (ppb)**	**Detection Limits**	**Dilution Factor**
First Choice Medical Supply LLC	**09/19/2005**	**212**	**50.0**	**50**
MicroFlex Corporation	**10/24/2005**	**72.1**	**1.0**	**1**
Kimberly-Clark	**10/24/2005**	**140**	**1.0**	**1**
Purple Nitrile Trademark of Kimberly -Clark	**01/23/2006**	**38.0**	**1.0**	**1**

ppb = parts per billion

Conclusions

Results from the investigation indicated the gloves were the source of carbon disulfide shown in analysis of groundwater samples collected on and around the Oak Ridge Reservation by TDEC/DOE-O personnel.

Failure to detect carbon disulfide in the various blanks, finding no issues of laboratory irregularities, and showing detections of carbon disulfide in each sample collected from the various gloves tested substantiates the carbon disulfide detections are sourced from cross contamination originating from the gloves used during sampling. Cross contamination from the glove material also explains the random distribution of detections of carbon disulfide observed in division analytical results. Table 2 displays the random carbon disulfide detections in 2005. The random carbon disulfide detections were from locations that did not have carbon disulfide detections in the past. Also, carbon disulfide was not consistently detected among those sample locations. Only four locations had repeat detections and three of the four were sampled on a monthly basis with the fourth on a quarterly basis. Therefore, the most logical explanation is that cross contamination from the gloves does occur and yields false positives for carbon disulfide.

Two significant questions arise from the findings in this report.

Are false positives for VOC and or other contaminants being generated by the materials commonly utilized for collecting water samples? This study indicates that for findings of carbon disulfide to be shown to be correct the gloves used during sample collection must be ruled out as a source for this particular VOC.

Is there a potential for deleterious health effects from carbon disulfide due to prolonged use of powder free latex gloves through skin absorption, for samplers and other professionals who routinely use protective gloves?

The Material Data Safety Sheet (MSDS) for carbon disulfide lists skin absorption as a potential health effect. Effects on health are of course outside the scope of this investigation and the expertise of the investigators, nevertheless and as constant users of protective gloves it is hoped that those with appropriate expertise will investigate the potential.

For environmental sampling it is clear that any finding for carbon disulfide, the gloves used by the samplers must be considered a potential source and any such contribution must be accounted for.

Table 2: Carbon Disulfide Detections in 2005

Location	Date	Results	Units	Dilution Factor	Sample Frequency
USGS 21-002 Spring	**03/16/05**	**2.20**	**ppb**	**1**	**Quarterly**
Bootlegger Spring	**05/24/05**	**153.00**	**ppb**	**5**	**Monthly**
Bootlegger Spring	**06/13/05**	**27.00**	**ppb**	**5**	**Monthly**
Bootlegger Spring	**08/04/05**	**2.04**	**ppb**	**5**	**Monthly**
Cattail Spring	**06/13/05**	**31.00**	**ppb**	**5**	**Monthly**
Cattail Spring	**08/04/05**	**5.20**	**ppb**	**1**	**Monthly**
Doug’s Drip Spring	**03/16/05**	**2.40**	**ppb**	**1**	**Quarterly**
Doug’s Drip Spring	**05/24/05**	**217.00**	**ppb**	**5**	**Quarterly**

Table 2: Carbon Disulfide Detections in 2005 (cont'd)

Location	Date	Results	Units	Dilution Factor	Sample Frequency
Gerry Spring	09/29/05	1.1	ppb	1	Quarterly
JA Jones Spring	03/16/05	2.80	ppb	5	Quarterly
Raccoon Creek Spring	09/29/05	11.00	ppb	1	Quarterly
Regina Loves Bobby Spring	06/02/05	67.00	ppb	5	Monthly
Substation Spring	06/21/05	13.00	ppb	5	Quarterly
Tree Root Spring	06/02/05	13.00	ppb	5	Quarterly
USGS 10-895 Spring	09/08/05	12.30	ppb	1	Monthly
USGS 10-895 Spring	10/11/05	8.15	ppb	1	Monthly
Wild Sweet Potato Spring	06/02/05	8.00	ppb	5	Quarterly
Zboil Spring	03/31/05	7.00	ppb	1	Quarterly

ppb = parts per billion

References

Baker, J.T. November 2001, Material Safety Data Sheet (MSDS) Mallinckrodt Chemicals. Phillipsburg, New Jersey.

Region IV EPA, May 1996, Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.

TDEC DOE-O 2005. *Environmental Monitoring Plan*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

TDEC DOE-O 1996. *Standard Operating Procedures*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

Thomasson, David 2005. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

APPENDIX B

Analytical Results for 2005
Groundwater Monitoring

Oak Ridge Reservation and Vicinity Independent Sampling Report

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
RWA-29	OFF	04/13/05	Gross Alpha	2.00	pCi/L	2.4		Alpha
RWA-29	OFF	04/13/05	Gross Beta	0.00	pCi/L	2.6		Beta
RWA-29	OFF	04/13/05	Pb-214	89.00	pCi/L	5.8		Gamma
RWA-29	OFF	04/13/05	Bi-214	95.00	pCi/L	6.6		Gamma
RWA-29	OFF	04/13/05	Arsenic	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Cadmium	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Calcium	41.90	mg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Chromium	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Cobalt	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Copper	3.00	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Iron	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Lead	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Magnesium	23.10	mg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Manganese	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Mercury	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Nickel	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Potassium	0.66	mg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Selenium	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Sodium	1.30	mg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	Thallium	U	µg/L			Gen. Inorganics
RWA-29	OFF	04/13/05	TCL Volatiles	U	µg/L			VOC
21-002 Sp.	K-25	03/16/05	Gross Alpha	1.20	pCi/l	1.8		Alpha
21-002 Sp.	K-25	03/16/05	Gross Beta	5.40	pCi/l	3		Beta
21-002 Sp.	K-25	03/16/05	Bi-214	76.10	pCi/l	5.5		Gamma
21-002 Sp.	K-25	03/16/05	Pb-214	117.20	pCi/l	6.6		Gamma
21-002 Sp.	K-25	03/16/05	Tc-99	7.40	pCi/l	3.2		Tc-99
21-002 Sp.	K-25	03/16/05	Carbon Disulfide	2.20	µg/L		1	VOC
21-002 Sp.	K-25	03/16/05	Carbon Tetrachloride	1.40	µg/L		1	VOC
21-002 Sp.	K-25	03/16/05	Trichloroethene	7.10	µg/L		1	VOC
21-002 Sp.	K-25	05/24/05	Carbon Tetrachloride	3.00	µg/L		2	VOC
21-002 Sp.	K-25	05/24/05	Trichloroethene	13.00	µg/L		5	VOC
21-002 Sp.	K-25	09/29/05	Carbon Tetrachloride	3.40	µg/L		1	VOC
21-002 Sp.	K-25	09/29/05	1,1-Dichloroethene	2.43	µg/L		1	VOC
21-002 Sp.	K-25	09/29/05	Trichloroethene	17.40	µg/L		1	VOC
BCK 4.55	Y-12	09/22/05	Gross Alpha	5.8	pCi/l	3.70		Alpha
BCK 4.55	Y-12	09/22/05	Gross Beta	6.7	pCi/l	3.10		Beta
BCK 4.55	Y-12	09/22/05	Bi-214	56.4	pCi/l	5.40		Gamma
BCK 4.55	Y-12	09/22/05	Pb-214	35.2	pCi/l	4.30		Gamma
BCK 4.55	Y-12	09/22/05	Nitrogen, Ammonia	U			0.1	Gen. Inorganics
BCK 4.55	Y-12	09/22/05	Nitrogen, NO3 & NO2	0.27			0.1	Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	Conductivity	326.00	umhos		0.5	Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	pH	7.70	pH units			Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	Dissolved Residue	190.00	mg/L		10	Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	Suspended Residue	U	mg/L		10	Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	Total Residue	207.00	mg/L		10	Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	Sulfate	7.00	mg/L		2	Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	NO3&NO2 Nitrogen	1.9	mg/L		0.01	Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	Nitrogen, Total Kjeldahl	0.41	mg/L		0.1	Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	Phosphorus, Total	U	mg/L		0.004	Gen. Inorganics
BCK 4.55 Weir	Y-12	07/12/05	Nitrogen, Ammonia	U	mg/L		0.02	Gen. Inorganics
BCK 4.78	Y-12	01/24/05	Gross Alpha	6.80	pCi/l	2.2		Alpha
BCK 4.78	Y-12	01/24/05	Gross Beta	5.10	pCi/l	2.8		Beta
BCK 4.78	Y-12	01/24/05	Bi-214	28.90	pCi/l	6.2		Gamma
BCK 4.78	Y-12	01/24/05	Tritium		pCi/l			H-3
BCK 4.78	Y-12	01/24/05	Tc-99		pCi/l			Tc-99

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
BCK 4.78	Y-12	05/09/05	Gross Alpha	9.50	pCi/l	3.8		Alpha
BCK 4.78	Y-12	05/09/05	Gross Beta	6.10	pCi/l	3		Beta
BCK 4.78	Y-12	05/09/05	Gamma	NDA	pCi/l			Gamma
BCK 4.78	Y-12	05/09/05	NO3&NO2 Nitrogen	2.10	mg/L	0.01	0.1	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Nitrogen, Total Kjeldahl	U	mg/L	0.1	0.1	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Phosphorus, Total	0.03	mg/L	0.004	0.004	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Nitrogen, Ammonia	U	mg/L	0.02	0.02	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Alkalinity	124.00	mg/L		10	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Chloride	5.00	mg/L		1	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Conductivity	244.00	umhos	6.2	0.5	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	pH	7.80	pH units			Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Dissolved Residue	144.00	mg/L		10	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Suspended Residue	U	mg/L		10	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Total Residue	147.00	mg/L		10	Gen. Inorganics
BCK 4.78	Y-12	05/09/05	Sulfate	6.00	mg/L		10	Gen. Inorganics
Bootlegger Sp.	Y-12	01/24/05	Gross Alpha	1.40	pCi/l	4.4		Alpha
Bootlegger Sp.	Y-12	01/24/05	Gross Beta	-0.10	pCi/l	5.3		Beta
Bootlegger Sp.	Y-12	01/24/05	Pb-214	28.90	pCi/l			Gamma
Bootlegger Sp.	Y-12	01/24/05	Bi-214	60.60	pCi/l			Gamma
Bootlegger Sp.	Y-12	01/24/05	Tritium		pCi/l	3.3		H-3
Bootlegger Sp.	Y-12	01/24/05	Tc-99		pCi/l	3.1		Tc-99
Bootlegger Sp.	Y-12	03/08/05	Gross Alpha	-1.50	pCi/l	2.5		Alpha
Bootlegger Sp.	Y-12	03/08/05	Gross Beta	0.10	pCi/l	2.6		Beta
Bootlegger Sp.	Y-12	03/08/05	Pb-214	13.60	pCi/l	3		Gamma
Bootlegger Sp.	Y-12	03/08/05	Bi-214	23.00	pCi/l	3.9		Gamma
Bootlegger Sp.	Y-12	04/25/05	Gross Alpha	-0.30	pCi/l	2.8		Alpha
Bootlegger Sp.	Y-12	04/25/05	Gross Beta	2.20	pCi/l	2.6		Beta
Bootlegger Sp.	Y-12	04/25/05	Pb-214	26.00	pCi/l	3.4		Gamma
Bootlegger Sp.	Y-12	04/25/05	Bi-214	30.40	pCi/l	3.7		Gamma
Bootlegger Sp.	Y-12	05/06/05	Gross Alpha	1.40	pCi/l	2.9		Alpha
Bootlegger Sp.	Y-12	05/06/05	Gross Beta	3.60	pCi/l	2.8		Beta
Bootlegger Sp.	Y-12	05/06/05	Gamma Radionuclides	NDA	pCi/l			Gamma
Bootlegger Sp.	Y-12	05/24/05	Carbon Disulfide	153.00	µg/L	5	5.00	VOC
Bootlegger Sp.	Y-12	05/24/05	1,1-Dichloroethane	1.50	µg/L	0.5	5.00	VOC
Bootlegger Sp.	Y-12	06/13/05	cis-1,2-Dichloroethene	1.40	µg/L		1.00	VOC
Bootlegger Sp.	Y-12	06/13/05	Carbon Disulfide	27.00	µg/L	5	5.00	VOC
Bootlegger Sp.	Y-12	07/06/05	Gross Alpha	2.20	pCi/l	1.6		Alpha
Bootlegger Sp.	Y-12	07/06/05	Gross Beta	-0.80	pCi/l	1.1		Beta
Bootlegger Sp.	Y-12	07/06/05	Pb-214	71.00	pCi/l	5.1		Gamma
Bootlegger Sp.	Y-12	07/06/05	Bi-214	116.00	pCi/l	7		Gamma
Bootlegger Sp.	Y-12	07/06/05	cis-1,2-Dichloroethene	1.58	µg/L		1.00	VOC
Bootlegger Sp.	Y-12	07/06/05	Tetrachloroethene	1.55	µg/L		1.00	VOC
Bootlegger Sp.	Y-12	08/04/05	Gross Alpha	0.80	pCi/l	2.7		Alpha
Bootlegger Sp.	Y-12	08/04/05	Gross Beta	1.20	pCi/l	2.8		Beta
Bootlegger Sp.	Y-12	08/04/05	Pb-212	11.40	pCi/l	3.2		Gamma
Bootlegger Sp.	Y-12	08/04/05	Pb-214	152.30	pCi/l	7.3		Gamma
Bootlegger Sp.	Y-12	08/04/05	Bi-214	197.70	pCi/l	8.6		Gamma
Bootlegger Sp.	Y-12	08/04/05	Carbon Disulfide	2.04	µg/L	5	5.00	VOC
Bootlegger Sp.	Y-12	08/04/05	1,1-Dichloroethane	1.31	µg/L	0.5	5.00	VOC
Bootlegger Sp.	Y-12	08/04/05	cis-1,2-Dichloroethene	2.26	µg/L		1.00	VOC
Bootlegger Sp.	Y-12	08/04/05	Tetrachloroethene	3.16	µg/L		1.00	VOC
Bootlegger Sp.	Y-12	09/08/05	Gross Alpha	-0.60	pCi/l	2.7		Alpha
Bootlegger Sp.	Y-12	09/08/05	Gross Beta	0.80	pCi/l	2.6		Beta
Bootlegger Sp.	Y-12	09/08/05	Pb-214	77.00	pCi/l	5.5		Gamma
Bootlegger Sp.	Y-12	09/08/05	Bi-214	77.10	pCi/l	5.6		Gamma

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
Bootlegger Sp.	Y-12	09/08/05	cis-1,2-Dichloroethene	2.04	µg/L		1.00	VOC
Bootlegger Sp.	Y-12	10/11/05	cis-1,2-Dichloroethene	1.80	µg/L		1.00	VOC
Bootlegger Sp.	Y-12	11/16/05	cis-1,2-Dichloroethene	1.93	µg/L		1.00	VOC
Bootlegger Sp.	Y-12	11/16/05	1,1-Dichloroethane	1.07	µg/L	0.5	1.00	VOC
Bootlegger Sp.	Y-12	11/16/05	Tetrachloroethene	1.80	µg/L		1.00	VOC
Burns Cem. Sp.	Y-12	02/02/05	Gross Alpha	0	pCi/l	1.8		Alpha
Burns Cem. Sp.	Y-12	02/02/05	Gross Beta	-0.2	pCi/l	2.6		Beta
Burns Cem. Sp.	Y-12	02/02/05	Pb-214	93	pCi/l	6.2		Gamma
Burns Cem. Sp.	Y-12	02/02/05	Bi-214	81.6	pCi/l	6		Gamma
CABN030905	Y-12	03/09/05	Gross Beta	1.20	pCi/l	2.6		Beta
CABN030905	Y-12	03/09/05	Pb-214	31.10	pCi/l	4.30		Gamma
CABN030905	Y-12	03/09/05	Bi-214	23.30	pCi/l	4.20		Gamma
CABN030905	Y-12	03/09/05	Chloride	U	mg/L		1.00	Gen. Inorganics
CABN030905	Y-12	03/09/05	Conductivity	171.00	umhos		0.5	Gen. Inorganics
CABN030905	Y-12	03/09/05	NO3&NO2 Nitrogen	0.10	mg/L		0.10	Gen. Inorganics
CABN030905	Y-12	03/09/05	pH	7.10	pH units			Gen. Inorganics
CABN030905	Y-12	03/09/05	Dissolved Residue	100.00	mg/L		10.00	Gen. Inorganics
CABN030905	Y-12	03/09/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
CABN030905	Y-12	03/09/05	Total Residue	114.00	mg/L		10.00	Gen. Inorganics
CABN030905	Y-12	03/09/05	Sulfate	5.00	mg/L		10	Gen. Inorganics
CABN030905	Y-12	03/09/05	Nitrogen, ammonia	U	µg/L		0.02	Gen. Inorganics
CABN030905	Y-12	03/09/05	Nitrogen, Total Kjeldahl	U	mg/L		0.1	Gen. Inorganics
CABN030905	Y-12	03/09/05	Phosphorus, Total	U	µg/L		0.004	Gen. Inorganics
CABN030905	Y-12	03/09/05	Aluminum	U	µg/L		100.00	Metals
CABN030905	Y-12	03/09/05	Antimony	U	µg/L		3.00	Metals
CABN030905	Y-12	03/09/05	Arsenic	2.00	µg/L		1.00	Metals
CABN030905	Y-12	03/09/05	Barium	U	µg/L		100.00	Metals
CABN030905	Y-12	03/09/05	Beryllium	U	µg/L		1.00	Metals
CABN030905	Y-12	03/09/05	Cadmium	U	µg/L		1.00	Metals
CABN030905	Y-12	03/09/05	Calcium	25.10	mg/L		2	Metals
CABN030905	Y-12	03/09/05	Chromium	U	µg/L		1	Metals
CABN030905	Y-12	03/09/05	Cobalt	U	µg/L		2.00	Metals
CABN030905	Y-12	03/09/05	Copper	U	µg/L		1	Metals
CABN030905	Y-12	03/09/05	Iron	276.00	µg/L		25.00	Metals
CABN030905	Y-12	03/09/05	Lead	U	µg/L		1.00	Metals
CABN030905	Y-12	03/09/05	Magnesium	11.60	mg/L		0.02	Metals
CABN030905	Y-12	03/09/05	Manganese	32.00	µg/L		5	Metals
CABN030905	Y-12	03/09/05	Mercury	U	µg/L		0.02	Metals
CABN030905	Y-12	03/09/05	Nickel	U	µg/L		10	Metals
CABN030905	Y-12	03/09/05	Potassium	0.78	mg/L		0.3	Metals
CABN030905	Y-12	03/09/05	Selenium	U	µg/L		2.00	Metals
CABN030905	Y-12	03/09/05	Silver	U	µg/L		1.00	Metals
CABN030905	Y-12	03/09/05	Sodium	0.80	mg/L		0.10	Metals
CABN030905	Y-12	03/09/05	Thallium	U	µg/L		2.00	Metals
CABN030905	Y-12	03/09/05	Vanadium	1.00	µg/L		2.00	Metals
CABN030905	Y-12	03/09/05	Zinc	5.00	µg/L		1.00	Metals
Cattail West	Y-12	01/28/05	Gross Alpha	1.60	pCi/l			Alpha
Cattail West	Y-12	01/28/05	Gross Beta	1.30	pCi/l			Beta
Cattail West	Y-12	01/28/05	Gamma Radionuclides	NDA	pCi/l			Gamma
Cattail West	Y-12	03/08/05	Gross Alpha	-0.50	pCi/l	3.5		Alpha
Cattail West	Y-12	03/08/05	Gross Beta	3.00	pCi/l	2.8		Beta
Cattail West	Y-12	03/08/05	Pb-214	18.60	pCi/l	4.9		Gamma
Cattail West	Y-12	03/08/05	Bi-214	20.30	pCi/l	3.9		Gamma
Cattail West	Y-12	04/25/05	Gross Alpha	-0.40	pCi/l	3.7		Alpha
Cattail West	Y-12	04/25/05	Gross Beta	2.50	pCi/l	2.7		Beta

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
Cattail West	Y-12	04/25/05	Pb-214	27.90	pCi/l	4.4		Gamma
Cattail West	Y-12	04/25/05	Bi-214	45.80	pCi/l	4.9		Gamma
Cattail West	Y-12	05/06/05	Gross Alpha	1.60	pCi/l	4		Alpha
Cattail West	Y-12	05/06/05	Gross Beta	2.20	pCi/l	2.7		Beta
Cattail West	Y-12	05/06/05	Gamma Radionuclides	NDA	pCi/l			Gamma
Cattail West	Y-12	05/06/05	TCL Volatiles	U	µg/L			VOC
Cattail West	Y-12	05/24/05	TCL Volatiles	U	µg/L			VOC
Cattail West	Y-12	06/13/05	Acetone	26.00	µg/L		2.50	VOC
Cattail West	Y-12	06/13/05	Carbon Disulfide	31.00	µg/L		5.00	VOC
Cattail West	Y-12	08/04/05	Gross Alpha	-1.80	pCi/l	3.3		Alpha
Cattail West	Y-12	08/04/05	Gross Beta	2.60	pCi/l	2.9		Beta
Cattail West	Y-12	08/04/05	Pb-214	39.20	pCi/l	4		Gamma
Cattail West	Y-12	08/04/05	Bi-214	51.70	pCi/l	4.8		Gamma
Cattail West	Y-12	08/04/05	Carbon Disulfide	5.20	µg/L		1.00	VOC
Cattail West Ck	Y-12	07/06/05	Gross Alpha	1.80	pCi/l	1.5		Alpha
Cattail West Ck	Y-12	07/06/05	Gross Beta	1.00	pCi/l	1.4		Beta
Cattail West Ck	Y-12	07/06/05	Pb-214	91.50	pCi/l	5.8		Gamma
Cattail West Ck	Y-12	07/06/05	Bi-214	173.90	pCi/l	8.6		Gamma
Cattail West Ck	Y-12	07/06/05	TCL Volatiles	U	µg/L			VOC
Cephus Sp.	Y-12	03/09/05	Gross Alpha	0.20	pCi/l	2.1		Alpha
Cephus Sp.	Y-12	03/09/05	Gross Beta	1.70	pCi/l	2.7		Beta
Cephus Sp.	Y-12	03/09/05	Gamma	NDA	pCi/l			Gamma
Cephus Sp.	Y-12	03/09/05	Alkalinity	66.00	mg/L		10.00	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Chloride	U	mg/L		1.00	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Conductivity	184.00	umohs		0.5	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	NO3&NO2 Nitrogen	0.07	mg/L		0.10	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	pH	7.60	pH units			Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Dissolved Residue	102.00	mg/L		10.00	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Total Residue	116.00	mg/L		10.00	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Sulfate	3.00	mg/L		10	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Nitrogen, ammonia	U	mg/L		0.02	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Nitrogen, Total Kjeldahl	U	mg/L		0.1	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Phosphorus, Total	U	mg/L		0.004	Gen. Inorganics
Cephus Sp.	Y-12	03/09/05	Aluminum	U	mg/L		100.00	Metals
Cephus Sp.	Y-12	03/09/05	Antimony	U	µg/L		3.00	Metals
Cephus Sp.	Y-12	03/09/05	Arsenic	U	µg/L		1.00	Metals
Cephus Sp.	Y-12	03/09/05	Barium	U	µg/L		100.00	Metals
Cephus Sp.	Y-12	03/09/05	Beryllium	U	µg/L		1.00	Metals
Cephus Sp.	Y-12	03/09/05	Cadmium	U	µg/L		1.00	Metals
Cephus Sp.	Y-12	03/09/05	Calcium	30.00	mg/L		2	Metals
Cephus Sp.	Y-12	03/09/05	Chromium	U	µg/L		1	Metals
Cephus Sp.	Y-12	03/09/05	Cobalt	U	µg/L		2.00	Metals
Cephus Sp.	Y-12	03/09/05	Copper	U	µg/L		1	Metals
Cephus Sp.	Y-12	03/09/05	Iron	262.00	µg/L		25.00	Metals
Cephus Sp.	Y-12	03/09/05	Lead	U	µg/L		1.00	Metals
Cephus Sp.	Y-12	03/09/05	Magnesium	10.50	mg/L		0.02	Metals
Cephus Sp.	Y-12	03/09/05	Manganese	72.00	µg/L		5	Metals
Cephus Sp.	Y-12	03/09/05	Mercury	U	µg/L		0.02	Metals
Cephus Sp.	Y-12	03/09/05	Nickel	U	µg/L		10	Metals
Cephus Sp.	Y-12	03/09/05	Potassium	0.80	mg/L		0.3	Metals
Cephus Sp.	Y-12	03/09/05	Selenium	U	mg/L		2.00	Metals
Cephus Sp.	Y-12	03/09/05	Silver	U	µg/L		1.00	Metals
Cephus Sp.	Y-12	03/09/05	Sodium	1.00	mg/L		0.10	Metals
Cephus Sp.	Y-12	03/09/05	Thallium	U	µg/L		2.00	Metals

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
Cephus Sp.	Y-12	03/09/05	Vanadium	U	µg/L		2.00	Metals
Cephus Sp.	Y-12	03/09/05	Zinc	2.00	µg/L		1.00	Metals
Cephus Sp.	Y-12	03/09/05	TCL Volatiles	U	µg/L			VOC
Crooked Tree Sp.	X-10	02/02/05	Gross Alpha	0.3	pCi/l	2.30		Alpha
Crooked Tree Sp.	X-10	02/02/05	Gross Beta	1	pCi/l	2.80		Beta
Crooked Tree Sp.	X-10	02/02/05	Pb-214	11.1	pCi/l	3.10		Gamma
Dead Horse Sp.	OFF	09/27/05	Aluminum	U	µg/L		100.00	Metals
Dead Horse Sp.	OFF	09/27/05	Antimony	U	µg/L		3.00	Metals
Dead Horse Sp.	OFF	09/27/05	Arsenic	U	µg/L		1.00	Metals
Dead Horse Sp.	OFF	09/27/05	Barium	U	µg/L		100.00	Metals
Dead Horse Sp.	OFF	09/27/05	Beryllium	U	µg/L		1.00	Metals
Dead Horse Sp.	OFF	09/27/05	Cadmium	U	µg/L		1.00	Metals
Dead Horse Sp.	OFF	09/27/05	Calcium	43.00	mg/L		2	Metals
Dead Horse Sp.	OFF	09/27/05	Chromium	U	µg/L		1	Metals
Dead Horse Sp.	OFF	09/27/05	Cobalt	U	µg/L		2.00	Metals
Dead Horse Sp.	OFF	09/27/05	Copper	2.00	µg/L		1	Metals
Dead Horse Sp.	OFF	09/27/05	Iron	U	µg/L		25.00	Metals
Dead Horse Sp.	OFF	09/27/05	Lead	U	µg/L		1.00	Metals
Dead Horse Sp.	OFF	09/27/05	Magnesium	19.10	mg/L		0.02	Metals
Dead Horse Sp.	OFF	09/27/05	Manganese	U	µg/L		5	Metals
Dead Horse Sp.	OFF	09/27/05	Mercury	U	µg/L		0.20	Metals
Dead Horse Sp.	OFF	09/27/05	Nickel	U	µg/L		10	Metals
Dead Horse Sp.	OFF	09/27/05	Potassium	1.00	mg/L		0.3	Metals
Dead Horse Sp.	OFF	09/27/05	Selenium	U	µg/L		2.00	Metals
Dead Horse Sp.	OFF	09/27/05	Silver	U	µg/L		1.00	Metals
Dead Horse Sp.	OFF	09/27/05	Sodium	0.60	mg/L		0.10	Metals
Dead Horse Sp.	OFF	09/27/05	Thallium	U	µg/L		2.00	Metals
Dead Horse Sp.	OFF	09/27/05	Vanadium	U	µg/L		2.00	Metals
Dead Horse Sp.	OFF	09/27/05	Zinc	1.00	µg/L		1.00	Metals
Dead Horse Sp.	OFF	09/27/05	TCL Volatiles	U	µg/L			VOC
Doug's Drip	K-25	02/02/05	Gross Alpha	0.60	pCi/l	1.6		Alpha
Doug's Drip	K-25	02/02/05	Gross Beta	2.70	pCi/l	2.7		Beta
Doug's Drip	K-25	02/02/05	Pb-214	12.60	pCi/l	3.4		Gamma
Doug's Drip	K-25	02/02/05	Tc-99	0.00	pCi/l	3.1		Tc-99
Doug's Drip	K-25	03/16/05	Gross Alpha	0.80	pCi/l	1.3		Alpha
Doug's Drip	K-25	03/16/05	Gross Beta	0.20	pCi/l	2.4		Beta
Doug's Drip	K-25	03/16/05	Gamma	NDA	pCi/l			Gamma
Doug's Drip	K-25	03/16/05	Tc-99	0.00	pCi/l	3.1		Tc-99
Doug's Drip	K-25	03/16/05	Carbon Disulfide	2.40	µg/L		1.00	VOC
Doug's Drip	K-25	05/24/05	Carbon Disulfide	217.00	µg/L	5	5.00	VOC
Firing Range Sp.	X-10	04/06/05	Gross Alpha	-1.30	pCi/l	2.4		Alpha
Firing Range Sp.	X-10	04/06/05	Gross Beta	3.50	pCi/l	2.6		Beta
Firing Range Sp.	X-10	04/06/05	Bi-214	11.00	pCi/l	3.1		Gamma
Firing Range Sp.	X-10	04/06/05	Tc-99	0.6	pCi/l	3.1		Tc-99
Gerry Sp.	X-10	09/29/05	Carbon Disulfide	1.1	µg/L		1	VOC
Ish Weir Sp.	X-10	06/14/05	Gross Alpha		pCi/l			Alpha
Ish Weir Sp.	X-10	06/14/05	Gross Beta		pCi/l			Beta
Ish Weir Sp.	X-10	06/14/05	Gamma		pCi/l			Gamma
Ish Weir Sp.	X-10	06/14/05	Arsenic	U	µg/L		1	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Beryllium	U	µg/L		1	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Cadmium	U	µg/L		1	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Calcium	28.60	mg/L		0.03	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Chromium	U	µg/L		1	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Cobalt	U	µg/L		10	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Copper	U	µg/L		1	Gen. Inorganics

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
Ish Weir Sp.	X-10	06/14/05	Iron	121.00	µg/L		25	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Lead	U	µg/L		1	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Magnesium	9.30	mg/L		0.02	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Manganese	40.00	µg/L		5	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Nickel	U	µg/L		10	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Potassium	0.70	mg/L		0.02	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Selenium	U	µg/L		2	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Sodium	0.90	mg/L		0.1	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Thallium	U	µg/L		2	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Zinc	3.00	µg/L		1.00	Gen. Inorganics
Ish Weir Sp.	X-10	06/14/05	Tritium					Tritium
JAJONES031605	K-25	03/16/05	Gross Alpha	12.20	pCi/l	5.4		Alpha
JAJONES031605	K-25	03/16/05	Gross Beta	3.70	pCi/l	3		Beta
JAJONES031605	K-25	03/16/05	Pb-214	42.60	pCi/l	4.6		Gamma
JAJONES031605	K-25	03/16/05	Bi-214	58.40	pCi/l	5.1		Gamma
JAJONES031605	K-25	03/16/05	Tc-99	1.80	pCi/l	3.1		Tc-99
JAJONES031605	K-25	03/16/05	Carbon Disulfide	2.80	µg/L		5.00	VOC
JAJONES031605	K-25	03/16/05	cis-1,2-Dichloroethene	42.30	µg/L		1.00	VOC
Lila's Leak Sp.	K-25	06/08/05	Gross Alpha	0.10	pCi/l	2.1		Alpha
Lila's Leak Sp.	K-25	06/08/05	Gross Beta	2.60	pCi/l	2.7		Beta
Lila's Leak Sp.	K-25	06/08/05	Pb-214	19.00	pCi/l	3.7		Gamma
Lila's Leak Sp.	K-25	06/08/05	Bi-214	58.00	pCi/l	5.3		Gamma
Lila's Leak Sp.	K-25	06/08/05	Arsenic	U	µg/L		1	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Beryllium	U	µg/L		1	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Cadmium	U	µg/L		1	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Calcium	36.90	mg/L		0.03	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Chromium	3.00	µg/L		1	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Cobalt	U	µg/L		10	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Copper	3.00	µg/L		1	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Iron	2900.00	µg/L		25	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Lead	4.00	µg/L		1	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Magnesium	14.10	mg/L		0.02	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Manganese	190.00	µg/L		5	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Nickel	U	µg/L		10	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Potassium	2.83	mg/L		0.02	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Selenium	U	µg/L		2	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Sodium	0.80	mg/L		0.1	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Thallium	U	µg/L		2	Gen. Inorganics
Lila's Leak Sp.	K-25	06/08/05	Zinc	15.00	µg/L		1.00	Gen. Inorganics
Love Sp.	OFF	09/20/05	Mercury	U	µg/L		0.20	Metals
Merak Sp.	K-25	05/24/05	TCL Volatiles	U	µg/L			VOC
Mossy Rock Sp.	Y-12	03/09/05	Gross Alpha	0.60	pCi/l	2.4		Alpha
Mossy Rock Sp.	Y-12	03/09/05	Gross Beta	1.20	pCi/l	2.7		Beta
Mossy Rock Sp.	Y-12	03/09/05	Pb-214	23.90	pCi/l	4		Gamma
Mossy Rock Sp.	Y-12	03/09/05	Bi-214	42.20	pCi/l	4.4		Gamma
Mossy Rock Sp.	Y-12	03/09/05	Alkalinity	83.00	mg/L		10.00	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	Chloride	U	µg/L		1.00	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	Conductivity	221.00	µg/L		0.5	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	NO3&NO2 Nitrogen	0.23	mg/L		0.10	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	pH	7.90	pH units			Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	Dissolved Residue	129.00	mg/L		10.00	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	Total Residue	142.00	mg/L		10.00	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	Sulfate	3.00	mg/L		10	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	Nitrogen, ammonia	U	mg/L		0.02	Gen. Inorganics

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
Mossy Rock Sp.	Y-12	03/09/05	Nitrogen, Total Kjeldahl	0.21	mg/L		0.1	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	Phosphorus, Total	U	mg/L		0.004	Gen. Inorganics
Mossy Rock Sp.	Y-12	03/09/05	Aluminum	U	µg/L		100.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Antimony	U	µg/L		3.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Arsenic	U	µg/L		1.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Barium	U	µg/L		100.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Beryllium	U	µg/L		1.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Cadmium	U	µg/L		1.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Calcium	39.30	mg/L		2	Metals
Mossy Rock Sp.	Y-12	03/09/05	Chromium	U	µg/L		1	Metals
Mossy Rock Sp.	Y-12	03/09/05	Cobalt	U	µg/L		2.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Copper	U	µg/L		1	Metals
Mossy Rock Sp.	Y-12	03/09/05	Iron	31.00	µg/L		25.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Lead	U	µg/L		1.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Magnesium	12.20	mg/L		0.02	Metals
Mossy Rock Sp.	Y-12	03/09/05	Manganese	U	µg/L		5	Metals
Mossy Rock Sp.	Y-12	03/09/05	Mercury	U	µg/L		0.02	Metals
Mossy Rock Sp.	Y-12	03/09/05	Nickel	U	µg/L		10	Metals
Mossy Rock Sp.	Y-12	03/09/05	Potassium	0.60	mg/L		0.3	Metals
Mossy Rock Sp.	Y-12	03/09/05	Selenium	U	µg/L		2.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Silver	U	µg/L		1.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Sodium	0.60	mg/L		0.10	Metals
Mossy Rock Sp.	Y-12	03/09/05	Thallium	U	µg/L		2.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Vanadium	U	µg/L		2.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Zinc	U	µg/L		1.00	Metals
Mossy Rock Sp.	Y-12	03/09/05	Chloroform	1.30	µg/L			VOC
New Weir	X-10	01/24/05	Gross Alpha	29.80	pCi/l			Alpha
New Weir	X-10	01/24/05	Gross Beta	22.50	pCi/l			Beta
New Weir	X-10	01/24/05	Bi-214	12.40	pCi/l			Gamma
New Weir	Y-12	05/09/05	Gross Alpha	25.50	pCi/l	6.2		Alpha
New Weir	Y-12	05/09/05	Gross Beta	17.70	pCi/l	3.9		Beta
New Weir	Y-12	05/09/05	Gamma	NDA	pCi/l			Gamma
New Weir	Y-12	05/09/05	NO3&NO2 Nitrogen	5.00	mg/L		0.10	Gen. Inorganics
New Weir	Y-12	05/09/05	Nitrogen, Total Kjeldahl	U	pCi/L		0.1	Gen. Inorganics
New Weir	Y-12	05/09/05	Phosphorus, Total	0.04	mg/L		0.004	Gen. Inorganics
New Weir	Y-12	05/09/05	Nitrogen, Ammonia	U	mg/L		0.02	Gen. Inorganics
New Weir	Y-12	05/09/05	Alkalinity	155.00	mg/L		10.00	Gen. Inorganics
New Weir	Y-12	05/09/05	Chloride	10.00	mg/L		1.00	Gen. Inorganics
New Weir	Y-12	05/09/05	Conductivity	356.00	umhos		0.5	Gen. Inorganics
New Weir	Y-12	05/09/05	pH	7.80	pH units			Gen. Inorganics
New Weir	Y-12	05/09/05	Dissolved Residue	216.00	mg/L		10.00	Gen. Inorganics
New Weir	Y-12	05/09/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
New Weir	Y-12	05/09/05	Total Residue	220.00	mg/L		10.00	Gen. Inorganics
New Weir	Y-12	05/09/05	Sulfate	11.00	µg/L		10	Gen. Inorganics
New Weir	Y-12	07/12/05	Alkalinity	183.00	mg/L		10.00	Gen. Inorganics
New Weir	Y-12	07/12/05	Chloride	14.00	mg/L		1.00	Gen. Inorganics
New Weir	Y-12	07/12/05	Conductivity	456.00	umhos		0.5	Gen. Inorganics
New Weir	Y-12	07/12/05	pH	7.80	pH units			Gen. Inorganics
New Weir	Y-12	07/12/05	Dissolved Residue	278.00	mg/L		10.00	Gen. Inorganics
New Weir	Y-12	07/12/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
New Weir	Y-12	07/12/05	Total Residue	306.00	mg/L		10.00	Gen. Inorganics
New Weir	Y-12	07/12/05	Sulfate	16.00	µg/L		2	Gen. Inorganics
New Weir	Y-12	07/12/05	NO3&NO2 Nitrogen	8.8	mg/L		0.2	Gen. Inorganics
New Weir	Y-12	07/12/05	Nitrogen, Total Kjeldahl	0.46	mg/L		0.1	Gen. Inorganics
New Weir	Y-12	07/12/05	Phosphorus, Total	U	mg/L		0.004	Gen. Inorganics

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
New Weir	Y-12	07/12/05	Nitrogen, Ammonia	U	mg/L		0.02	Gen. Inorganics
New Weir	Y-12	09/22/05	Gross Alpha	30.3	pCi/l	8.30		Alpha
New Weir	Y-12	09/22/05	Gross Beta	32.5	pCi/l	4.70		Beta
New Weir	Y-12	09/22/05	Gamma Radionuclides	NDA	pCi/l			Gamma
New Weir	Y-12	09/22/05	Nitrogen, Ammonia	U			0.1	Gen. Inorganics
New Weir	Y-12	09/22/05	Nitrogen, NO3 & NO2	42.50			2.5	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Gross Alpha	0.90	pCi/l	3.1		Alpha
Parcel 10 Sp.	K-25	06/08/05	Gross Beta	1.50	pCi/l	2.7		Beta
Parcel 10 Sp.	K-25	06/08/05	Gamma	NDA	pCi/l			Gamma
Parcel 10 Sp.	K-25	06/08/05	Arsenic	U	µg/L		1	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Beryllium	U	µg/L		1	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Cadmium	U	µg/L		1	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Calcium	104.00	mg/L		0.03	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Chromium	U	µg/L		1	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Cobalt	U	µg/L		10	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Copper	U	µg/L		1	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Iron	440.00	µg/L		25	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Lead	6.00	µg/L		1	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Magnesium	13.20	mg/L		0.02	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Manganese	24.00	µg/L		5	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Nickel	12.00	µg/L		10	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Potassium	1.21	mg/L		0.02	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Selenium	U	µg/L		2	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Sodium	0.90	mg/L		0.1	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Thallium	U	µg/L		2	Gen. Inorganics
Parcel 10 Sp.	K-25	06/08/05	Zinc	50.00	µg/L		1.00	Gen. Inorganics
Raccoon Creek Sp.	X-10	03/30/05	Gross Alpha	0.70	pCi/l	1.9		Alpha
Raccoon Creek Sp.	X-10	03/30/05	Gross Beta	3.00	pCi/l	2.5		Beta
Raccoon Creek Sp.	X-10	03/30/05	Bi-214	31.50	pCi/l	4		Gamma
Raccoon Creek Sp.	X-10	03/30/05	Pb-214	28.60	pCi/l	4.6		Gamma
Raccoon Creek Sp.	X-10	03/30/05	TCL Volatiles	U	µg/L			VOC
Raccoon Creek Sp.	X-10	09/29/05	Carbon Disulfide	11.00	µg/L		1.00	VOC
ReginaLovesBobby	K-25	06/02/05	Gross Alpha	-0.70	pCi/l	2.1		Alpha
ReginaLovesBobby	K-25	06/02/05	Gross Beta	2.00	pCi/l	2.7		Beta
ReginaLovesBobby	K-25	06/02/05	Gamma	NDA	pCi/l			Gamma
ReginaLovesBobby	K-25	06/02/05	Arsenic	U	µg/L		1	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Beryllium	U	µg/L		1	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Cadmium	U	µg/L		1	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Calcium	45.6	mg/L		0.03	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Chromium	U	µg/L		1	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Copper	U	µg/L		1	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Iron	139	µg/L		25	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Lead	U	µg/L		1	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Manganese	17.00	µg/L		5	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Nickel	U	µg/L		10	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Selenium	U	mg/L		2	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Thallium	U	µg/L		2	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Zinc	6	µg/L		1	Gen. Inorganics
ReginaLovesBobby	K-25	06/02/05	Tritium	1610.00	pCi/l	199		H-3
ReginaLovesBobby	K-25	06/02/05	Tc-99	2.00	pCi/l	3.2		Tc-99
ReginaLovesBobby	K-25	06/02/05	Carbon Disulfide	67.00	µg/L		5.00	VOC
ReginaLovesBobby	K-26	09/20/05	Mercury	U	µg/L		0.20	Metals
ReginaLovesBobby	K-25	10/11/05	Mercury	U	µg/L		0.20	Metals
ReginaLovesBobby	K-25	10/11/05	Volatile Organics	ND	µg/L			VOC
ReginaLovesBobby	K-25	11/16/05	TCL Volatiles	U	µg/L			VOC

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
Rifle Range Sp.	X-10	06/13/05	Gross Alpha		pCi/l			Alpha
Rifle Range Sp.	X-10	06/13/05	Gross Beta		pCi/l			Beta
Rifle Range Sp.	X-10	06/13/05	Gamma		pCi/l			Gamma
Rifle Range Sp.	X-10	06/13/05	Arsenic	U	µg/L		1	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Beryllium	U	µg/L		1	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Cadmium	U	µg/L		1	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Calcium	32.00	mg/L		0.03	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Chromium	U	µg/L		1	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Cobalt	U	µg/L		10	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Copper	U	µg/L		1	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Iron	37.00	µg/L		25	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Lead	U	µg/L		1	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Magnesium	13.20	mg/L		0.02	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Manganese	U	µg/L		5	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Nickel	U	µg/L		10	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Potassium	0.60	mg/L		0.02	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Selenium	U	µg/L		2	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Sodium	0.40	mg/L		0.1	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Thallium	U	µg/L		2	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	Zinc	4.00	µg/L		1.00	Gen. Inorganics
Rifle Range Sp.	X-10	06/13/05	H-3		pCi/l			Tritium
Rifle Range Sp.	X-10	06/13/05	TCL Volatiles	U	µg/L			VOC
Rose Bailey Sp.	OFF	09/20/05	Aluminum	344	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Antimony	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Arsenic	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Barium	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Beryllium	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Cadmium	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Calcium	53	mg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Chromium, total	1	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Cobalt	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Copper	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Iron	303	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Lead	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Magnesium	16.2	mg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Manganese	28	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Mercury	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Nickel	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Potassium	1	mg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Selenium	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Silver	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Sodium	2.1	mg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Thallium	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Vanadium	U	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Zinc	4	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	TCL Volatiles	ND	µg/L		0.20	Metals
Rose Bailey Sp.	OFF	09/20/05	Gross Alpha	1.1	pCi/l	2.9		Alpha
Rose Bailey Sp.	OFF	09/20/05	Gross Beta	2.7	pCi/l	2.7		Beta
Rose Bailey Sp.	OFF	09/20/05	Pb-214	68.5	pCi/l	5.2		Gamma
Rose Bailey Sp.	OFF	09/20/05	Bi-214	97.9	pCi/l	6.7		Gamma
Rose Bailey Sp.	OFF	09/20/05	Tritium	-219	pCi/l	192		H-3

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
Rose Bailey Sp.	OFF	09/20/05	Tc-99	3.4	pCi/l	3.2		Tc-99
RWA 22	OFF	10/18/05	Volatiles	ND	µg/L			VOC
RWA 22	OFF	10/18/05	Aluminum	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Antimony	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Arsenic	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Barium	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Beryllium	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Cadmium	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Calcium	12	mg/L		0.20	Metals
RWA 22	OFF	10/18/05	Chromium, total	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Cobalt	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Copper	26	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Iron	67	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Lead	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Magnesium	9.6N	mg/L		0.20	Metals
RWA 22	OFF	10/18/05	Manganese	5	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Mercury	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Nickel	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Potassium	7	mg/L		0.20	Metals
RWA 22	OFF	10/18/05	Selenium	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Silver	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Sodium	258	mg/L		0.20	Metals
RWA 22	OFF	10/18/05	Thallium	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Vanadium	U	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Zinc	12	µg/L		0.20	Metals
RWA 22	OFF	10/18/05	Gross Alpha	0	pCi/l	12		Alpha
RWA 22	OFF	10/18/05	Gross Beta	1.2	pCi/l	5.0		Beta
RWA 22	OFF	10/18/05	Pb-214	68.6	pCi/l	5.4		Gamma
RWA 22	OFF	10/18/05	Bi-214	118.2	pCi/l	7.1		Gamma
RWA 22	OFF	10/18/05	Tritium	204	pCi/l	183		H-3
RWA 56	OFF	10/18/05	Volatiles	ND	µg/L			VOC
RWA 56	OFF	10/18/05	Aluminum	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Antimony	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Arsenic	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Barium	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Beryllium	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Cadmium	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Calcium	15	mg/L		0.20	Metals
RWA 56	OFF	10/18/05	Chromium, total	2	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Cobalt	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Copper	7	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Iron	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Lead	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Magnesium	9.6N	mg/L		0.20	Metals
RWA 56	OFF	10/18/05	Manganese	5	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Mercury	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Nickel	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Potassium	1.7	mg/L		0.20	Metals
RWA 56	OFF	10/18/05	Selenium	U	µg/L		0.20	Metals

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
RWA 56	OFF	10/18/05	Silver	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Sodium	29	mg/L		0.20	Metals
RWA 56	OFF	10/18/05	Thallium	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Vanadium	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Zinc	U	µg/L		0.20	Metals
RWA 56	OFF	10/18/05	Gross Alpha	-0.2	pCi/l	2.9		Alpha
RWA 56	OFF	10/18/05	Gross Beta	2.0	pCi/l	2.8		Beta
RWA 56	OFF	10/18/05	Pb-214	65.0	pCi/l	5.6		Gamma
RWA 56	OFF	10/18/05	Bi-214	141.7	pCi/l	7.3		Gamma
RWA 56	OFF	10/18/05	Tritium	204	pCi/l	183		H-3
RWA 65	OFF	10/18/05	Volatiles	ND	µg/L			VOC
RWA 65	OFF	10/18/05	Aluminum	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Antimony	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Arsenic	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Barium	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Beryllium	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Cadmium	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Calcium	31	mg/L		0.20	Metals
RWA 65	OFF	10/18/05	Chromium, total	2	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Cobalt	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Copper	21	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Iron	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Lead	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Magnesium	9.6N	mg/L		0.20	Metals
RWA 65	OFF	10/18/05	Manganese	5	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Mercury	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Nickel	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Potassium	1.8	mg/L		0.20	Metals
RWA 65	OFF	10/18/05	Selenium	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Silver	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Sodium	2.2	mg/L		0.20	Metals
RWA 65	OFF	10/18/05	Thallium	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Vanadium	U	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Zinc	26	µg/L		0.20	Metals
RWA 65	OFF	10/18/05	Gross Alpha	1.2	pCi/l	2.3		Alpha
RWA 65	OFF	10/18/05	Gross Beta	2.3	pCi/l	2.7		Beta
RWA 65	OFF	10/18/05	Pb-214	80.1	pCi/l	5.8		Gamma
RWA 65	OFF	10/18/05	Bi-214	134.5	pCi/l	7.1		Gamma
RWA 65	OFF	10/18/05	Tritium	202	pCi/l	181		H-3
RWA 74	OFF	10/18/05	Volatiles	ND	µg/L			VOC
RWA 74	OFF	10/18/05	Aluminum	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Antimony	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Arsenic	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Barium	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Beryllium	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Cadmium	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Calcium	39	mg/L		0.20	Metals
RWA 74	OFF	10/18/05	Chromium, total	2	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Cobalt	U	µg/L		0.20	Metals

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
RWA 74	OFF	10/18/05	Copper	21	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Iron	29	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Lead	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Magnesium	9.6N	mg/L		0.20	Metals
RWA 74	OFF	10/18/05	Manganese	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Mercury	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Nickel	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Potassium	2	mg/L		0.20	Metals
RWA 74	OFF	10/18/05	Selenium	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Silver	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Sodium	25	mg/L		0.20	Metals
RWA 74	OFF	10/18/05	Thallium	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Vanadium	U	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Zinc	18	µg/L		0.20	Metals
RWA 74	OFF	10/18/05	Gross Alpha	-1.7	pCi/l	3.3		Alpha
RWA 74	OFF	10/18/05	Gross Beta	3.1	pCi/l	2.8		Beta
RWA 74	OFF	10/18/05	Pb-212	13.4	pCi/l	2.5		Gamma
RWA 74	OFF	10/18/05	Pb-214	48.4	pCi/l	5.3		Gamma
RWA 74	OFF	10/18/05	Bi-214	67.9	pCi/l	5.6		Gamma
RWA 74	OFF	10/18/05	Tritium	409	pCi/l	188		H-3
SNS-1 Sp.	X-10	01/26/05	Gross Alpha	0.20	pCi/l			Alpha
SNS-1 Sp.	X-10	01/26/05	Gross Beta	1.70	pCi/l			Beta
SNS-1 Sp.	X-10	01/26/05	Pb-214	NDA	pCi/l			Gamma
SNS-1 Sp.	X-10	01/26/05	Bi-214	NDA	pCi/l			Gamma
SNS-1 Sp.	X-10	08/29/05	Mercury	U	µg/L		0.20	Metals
SNS-4 Sp.	X-10	01/24/05	Gross Alpha	0.70	pCi/l			Alpha
SNS-4 Sp.	X-10	01/24/05	Gross Beta	0.80	pCi/l			Beta
SNS-4 Sp.	X-10	01/24/05	Pb-214	52.40	pCi/l			Gamma
SNS-4 Sp.	X-10	01/24/05	Bi-214	63.20	pCi/l			Gamma
SNS-4 Sp.	Y-12	01/24/05	Alkalinity	110.00	mg/L		10.00	Gen. Inorganics
SNS-4 Sp.	Y-12	01/24/05	Chloride	2.00	mg/L		1.00	Gen. Inorganics
SNS-4 Sp.	Y-12	01/24/05	Dissolved Residue	52.00	mg/L		10.00	Gen. Inorganics
SNS-4 Sp.	Y-12	01/24/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
SNS-4 Sp.	Y-12	01/24/05	Nitrogen, Ammonia		mg/L		0.02	Gen. Inorganics
SNS-4 Sp.	Y-12	01/24/05	NO3&NO2 Nitrogen		mg/L		0.10	Gen. Inorganics
SNS-4 Sp.	Y-12	01/24/05	Nitrogen, Total Kjeldahl		mg/L		0.1	Gen. Inorganics
SNS-4 Sp.	Y-12	01/24/05	Phosphorus, Total		mg/L		0.004	Gen. Inorganics
SNS-4 Sp.	Y-12	01/24/05	Arsenic	U	µg/L		1.00	Metals
SNS-4 Sp.	Y-12	01/24/05	Cadmium	U	µg/L		1.00	Metals
SNS-4 Sp.	Y-12	01/24/05	Calcium	28.50	mg/L		2	Metals
SNS-4 Sp.	Y-12	01/24/05	Chromium	1.00	µg/L		1	Metals
SNS-4 Sp.	Y-12	01/24/05	Cobalt	U	µg/L		2.00	Metals
SNS-4 Sp.	Y-12	01/24/05	Copper	2.00	µg/L		1	Metals
SNS-4 Sp.	Y-12	01/24/05	Iron	1320.00	µg/L		25.00	Metals
SNS-4 Sp.	Y-12	01/24/05	Magnesium	14.20	mg/L		0.02	Metals
SNS-4 Sp.	Y-12	01/24/05	Manganese	90.00	µg/L		5	Metals
SNS-4 Sp.	Y-12	01/24/05	Mercury		µg/L		0.02	Metals
SNS-4 Sp.	Y-12	01/24/05	Nickel	U	µg/L		10	Metals
SNS-4 Sp.	Y-12	01/24/05	Potassium	1.09	mg/L		0.3	Metals
SNS-4 Sp.	Y-12	01/24/05	Selenium	U	µg/L		2.00	Metals
SNS-4 Sp.	Y-12	01/24/05	Sodium	0.50	mg/L		0.10	Metals
SNS-4 Sp.	Y-12	01/24/05	Thallium	U	µg/L		2.00	Metals
SNS-4 Sp.	Y-12	01/24/05	Zinc	17.00	µg/L		1.00	Metals

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
SNS-4 Sp.	Y-12	01/24/05	Lead	7.00	µg/L		1.00	Metals
SNS-4 Sp.	Y-12	01/24/05	Trichlorofluoromethane	1.00	µg/L			VOC
SNS-4 Sp.	X-10	07/07/05	Gross Alpha	1.20	pCi/l	1		Alpha
SNS-4 Sp.	X-10	07/07/05	Gross Beta	-0.20	pCi/l	1.1		Beta
SNS-4 Sp.	X-10	07/07/05	Pb-214	31.80	pCi/l	4.5		Gamma
SNS-4 Sp.	X-10	07/07/05	Bi-214	57.20	pCi/l	5.8		Gamma
SNS-4 Sp.	X-10	08/29/05	Mercury	U	µg/L		0.20	Metals
SNS-6 Sp.	X-10	01/26/05	Gross Alpha	0.60	pCi/l			Alpha
SNS-6 Sp.	X-10	01/26/05	Gross Beta	-0.70	pCi/l			Beta
SNS-6 Sp.	X-10	01/26/05	Pb-214	28.00	pCi/l			Gamma
SNS-6 Sp.	X-10	01/26/05	Bi-214	42.80	pCi/l			Gamma
SNS-6 Sp.	X-10	01/26/05	Tritium		pCi/l			H-3
SNS-6 Sp.	X-10	01/26/05	Tc-99		pCi/l			Tc-99
SNS-6 Sp.	X-10	03/11/05	Aluminum	151.00	µg/L		100.00	Metals
SNS-6 Sp.	X-10	03/11/05	Antimony	U	µg/L		3.00	Metals
SNS-6 Sp.	X-10	03/11/05	Arsenic	1.00	µg/L		1.00	Metals
SNS-6 Sp.	X-10	03/11/05	Barium	U	µg/L		100.00	Metals
SNS-6 Sp.	X-10	03/11/05	Beryllium	U	µg/L		1.00	Metals
SNS-6 Sp.	X-10	03/11/05	Cadmium	U	µg/L		1.00	Metals
SNS-6 Sp.	X-10	03/11/05	Calcium	17.30	mg/L		2	Metals
SNS-6 Sp.	X-10	03/11/05	Chromium	U	µg/L		1	Metals
SNS-6 Sp.	X-10	03/11/05	Cobalt	U	µg/L		2.00	Metals
SNS-6 Sp.	X-10	03/11/05	Copper	U	µg/L		1	Metals
SNS-6 Sp.	X-10	03/11/05	Iron	454.00	µg/L		25.00	Metals
SNS-6 Sp.	X-10	03/11/05	Lead	U	µg/L		1.00	Metals
SNS-6 Sp.	X-10	03/11/05	Magnesium	6.19	mg/L		0.02	Metals
SNS-6 Sp.	X-10	03/11/05	Manganese	512.00	µg/L		5	Metals
SNS-6 Sp.	X-10	03/11/05	Mercury	U	µg/L		0.02	Metals
SNS-6 Sp.	X-10	03/11/05	Nickel	U	mg/L		10	Metals
SNS-6 Sp.	X-10	03/11/05	Potassium	0.96	mg/L		0.3	Metals
SNS-6 Sp.	X-10	03/11/05	Selenium	2.00	µg/L		2.00	Metals
SNS-6 Sp.	X-10	03/11/05	Silver	U	µg/L		1.00	Metals
SNS-6 Sp.	X-10	03/11/05	Sodium	1.00	mg/L		0.10	Metals
SNS-6 Sp.	X-10	03/11/05	Thallium	U	µg/L		2.00	Metals
SNS-6 Sp.	X-10	03/11/05	Vanadium	U	mg/L		2.00	Metals
SNS-6 Sp.	X-10	03/11/05	Zinc	13.00	µg/L		1.00	Metals
SNS-6 Sp.	X-10	08/29/05	Mercury	0.20	µg/L		0.20	Metals
SS-5 Sp.	X-10	01/24/05	Gross Alpha	8.90	pCi/l			Alpha
SS-5 Sp.	X-10	01/24/05	Gross Beta	9.20	pCi/l			Beta
SS-5 Sp.	X-10	01/24/05	Pb-214	47.00	pCi/l			Gamma
SS-5 Sp.	X-10	01/24/05	Bi-214	61.30	pCi/l			Gamma
SS-5 Sp.	X-10	01/24/05	Tritium		pCi/l			H-3
SS-5 Sp.	X-10	01/24/05	Tc-99		pCi/l			Tc-99
SS-5 Sp.	Y-12	05/09/05	Gross Alpha	11.60	pCi/l	4.4		Alpha
SS-5 Sp.	Y-12	05/09/05	Gross Beta	8.30	pCi/l	3.2		Beta
SS-5 Sp.	Y-12	05/09/05	Gamma	NDA	pCi/l			Gamma
SS-5 Sp.	Y-12	05/09/05	NO3&NO2 Nitrogen	2.80	mg/L		0.10	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	Nitrogen, Total Kjeldahl	U	µg/L		0.1	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	Phosphorus, Total	0.04	µg/L		0.004	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	Nitrogen, Ammonia	U	µg/L		0.02	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	Alkalinity	153.00	mg/L		10.00	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	Chloride	6.00	µg/L		1.00	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	Conductivity	297.00	µg/L		0.5	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	pH	7.40	pH units			Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	Dissolved Residue	178.00	mg/L		10.00	Gen. Inorganics

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
SS-5 Sp.	Y-12	05/09/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	Total Residue	186.00	mg/L		10.00	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	Sulfate	8.00	µg/L		10	Gen. Inorganics
SS-5 Sp.	Y-12	05/09/05	TCL Volatiles	U	µg/L			VOC
SS-5 Sp.	Y-12	07/07/05	Gross Alpha	18.50	pCi/l	4.3		Alpha
SS-5 Sp.	Y-12	07/07/05	Gross Beta	19.90	pCi/l	3.2		Beta
SS-5 Sp.	Y-12	07/07/05	Gamma	NDA	pCi/l			Gamma
SS-5 Sp.	Y-12	07/07/05	Alkalinity	196.00	mg/L		10.00	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	Chloride	13.00	µg/L		1.00	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	Conductivity	451.00	µg/L		0.5	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	pH	7.20	pH units			Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	Dissolved Residue	293.00	mg/L		10.00	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	Suspended Residue	13.00	mg/L		10.00	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	Total Residue	311.00	mg/L		10.00	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	Sulfate	14.00	µg/L		10	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	NO3&NO2 Nitrogen	0.67	mg/L		0.01	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	Nitrogen, Total Kjeldahl	0.36	mg/L		0.1	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	Phosphorus, Total	0.18	mg/L		0.004	Gen. Inorganics
SS-5 Sp.	Y-12	07/07/05	Nitrogen, Ammonia	0.04	mg/L		0.02	Gen. Inorganics
SS-5 Sp.	Y-12	09/22/05	Gross Alpha	34.0	pCi/l	8.80		Alpha
SS-5 Sp.	Y-12	09/22/05	Gross Beta	31.9	pCi/l	4.70		Beta
SS-5 Sp.	Y-12	09/22/05	Bi-214	50.3	pCi/l	5.00		Gamma
SS-5 Sp.	Y-12	09/22/05	Pb-214	24.7	pCi/l	4.10		Gamma
SS-5 Sp.	Y-12	09/22/05	Tl-208	7.0	pCi/l	2.10		Gamma
SS-5 Sp.	Y-12	09/22/05	Nitrogen, Ammonia	U			0.1	Gen. Inorganics
SS-5 Sp.	Y-12	09/22/05	Nitrogen, NO3 & NO2	6.80			1	Gen. Inorganics
SS-5 Sp.	Y-12	11/09/05	Bromomethane	1.00	µg/L		1.00	VOC
SS-5 Sp.	Y-12	11/09/05	1,1-Dichloroethane	1.35	µg/L		1.00	VOC
SS-5 Sp.	Y-12	11/09/05	1,1-Dichloroethene	1.17	µg/L		1.00	VOC
SS-5 Sp.	Y-12	11/09/05	cis-1,2-Dichloroethene	9.09	µg/L		1.00	VOC
SS-5 Sp.	Y-12	11/09/05	Trichloroethene	3.51	µg/L		1.00	VOC
SS-6 Sp.	Y-12	04/06/05	Gross Alpha	-0.3	pCi/l	2.00		Alpha
SS-6 Sp.	Y-12	04/06/05	Gross Beta	2.6	pCi/l	2.50		Beta
SS-6 Sp.	Y-12	04/06/05	Bi-214	19.7	pCi/l	4.20		Gamma
SS-6 Sp.	Y-12	04/06/05	Tc-99	0.3	pCi/l	3.10		Tc-99
SS-6 Sp.	Y-12	09/22/05	Gross Alpha	9.6	pCi/l	4.80		Alpha
SS-6 Sp.	Y-12	09/22/05	Gross Beta	8.2	pCi/l	3.20		Beta
SS-6 Sp.	Y-12	09/22/05	Bi-214	117.3	pCi/l	6.60		Gamma
SS-6 Sp.	Y-12	09/22/05	Pb-212	9.7	pCi/l	2.30		Gamma
SS-6 Sp.	Y-12	09/22/05	Pb-214	95.2	pCi/l	7.00		Gamma
SS-6 Sp.	Y-12	09/22/05	Nitrogen, Ammonia	U			0.1	Gen. Inorganics
SS-6 Sp.	Y-12	09/22/05	Nitrogen, NO3 & NO2	1.24			0.1	Gen. Inorganics
SS-6 Sp. Dup.	Y-12	04/06/05	Gross Alpha	0.5	pCi/l	2.10		Alpha
SS-6 Sp. Dup.	Y-12	04/06/05	Gross Beta	2	pCi/l	2.50		Beta
SS-7 Sp.	Y-12	02/02/05	Gross Alpha	2.6	pCi/l	2.60		Alpha
SS-7 Sp.	Y-12	02/02/05	Gross Beta	1.3	pCi/l	2.80		Beta
SS-7 Sp.	Y-12	02/02/05	Bi-214	26.7	pCi/l	3.90		Gamma
SS-7 Sp.	Y-12	02/02/05	Pb-214	41.5	pCi/l	4.50		Gamma
SS-7 Sp.	Y-12	02/02/05	COD	U	pCi/L			Gen. Inorganics
SS-7 Sp.	Y-12	02/02/05	NO3&NO2 Nitrogen	0.40	mg/L		0.10	Gen. Inorganics
SS-7 Sp.	Y-12	02/02/05	Nitrogen, Total Kjeldahl	U	mg/L		0.1	Gen. Inorganics
SS-7 Sp.	Y-12	02/02/05	Phosphorus, Total	U	mg/L		0.004	Gen. Inorganics
SS-7 Sp.	Y-12	02/02/05	Nitrogen, Ammonia	U	mg/L		0.02	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Gross Alpha	0.20	pCi/l	2.3		Alpha
SS-7 Sp.	Y-12	05/09/05	Gross Beta	2.30	pCi/l	2.6		Beta

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
SS-7 Sp.	Y-12	05/09/05	Gamma	NDA	pCi/l			Gamma
SS-7 Sp.	Y-12	05/09/05	NO3&NO2 Nitrogen	2.50	mg/L		0.10	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Nitrogen, Total Kjeldahl	U	pH Units		0.1	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Phosphorus, Total	0.04	mg/L		0.004	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Nitrogen, Ammonia	0.04	mg/L		0.02	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Alkalinity	125.00	mg/L		10.00	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Chloride	3.00	mg/L		1.00	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Conductivity	225.00	µg/L		0.5	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	pH	7.30	pH units			Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Dissolved Residue	126.00	mg/L		10.00	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Total Residue	134.00	mg/L		10.00	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	Sulfate	3.00	mg/L		2	Gen. Inorganics
SS-7 Sp.	Y-12	05/09/05	TCL Volatiles	U	µg/L			VOC
SS-7 Sp.	Y-12	07/07/05	Gross Alpha	7.30	pCi/l	2.4		Alpha
SS-7 Sp.	Y-12	07/07/05	Gross Beta	2.60	pCi/l	1.7		Beta
SS-7 Sp.	Y-12	07/07/05	Gamma	89.20	pCi/l	5.8		Gamma
SS-7 Sp.	Y-12	07/07/05	Gamma	113.80	pCi/l	7		Gamma
SS-7 Sp.	Y-12	07/07/05	Alkalinity	165.00	mg/L		10.00	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	Chloride	5.00	mg/L		1.00	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	Conductivity	319.00	µg/L		0.5	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	pH	7.20	pH units			Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	Dissolved Residue	188.00	mg/L		10.00	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	Total Residue	211.00	mg/L		10.00	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	Sulfate	5.00	mg/L		2	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	NO3&NO2 Nitrogen	5.20	mg/L		0.20	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	Nitrogen, Total Kjeldahl	U	mg/L		0.1	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	Phosphorus, Total	U	mg/L		0.004	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	Nitrogen, Ammonia	U	mg/L		0.02	Gen. Inorganics
SS-7 Sp.	Y-12	07/07/05	TCL Volatiles	U	µg/L			VOC
SS-7 Sp.	Y-12	09/22/05	Gross Alpha	9.7	pCi/l	4.80		Alpha
SS-7 Sp.	Y-12	09/22/05	Gross Beta	8.5	pCi/l	3.20		Beta
SS-7 Sp.	Y-12	09/22/05	Bi-214	206.1	pCi/l	6.60		Gamma
SS-7 Sp.	Y-12	09/22/05	Pb-212	18.9	pCi/l	2.30		Gamma
SS-7 Sp.	Y-12	09/22/05	Pb-214	114	pCi/l	7.00		Gamma
SS-7 Sp.	Y-12	09/22/05	Nitrogen, Ammonia	U			0.1	Gen. Inorganics
SS-7 Sp.	Y-12	09/22/05	Nitrogen, NO3 & NO2	0.41			0.1	Gen. Inorganics
SS-7 Sp. DUP.	Y-12	05/09/05	Gross Alpha	0.90	pCi/l	2.5		Alpha
SS-7 Sp. DUP.	Y-12	05/09/05	Gross Beta	2.40	pCi/l	2.6		Beta
SS-8 Sp.	Y-12	06/25/05	Gross Alpha	0.10	pCi/l	2.3		Alpha
SS-8 Sp.	Y-12	06/25/05	Gross Beta	-0.50	pCi/l	2.7		Beta
SS-8 Sp.	Y-12	06/25/05	Tl-208	6.50	pCi/l	1.7		Gamma
SS-8 Sp.	Y-12	06/25/05	Pb-214	27.20	pCi/l	3.7		Gamma
SS-8 Sp.	Y-12	06/25/05	Bi-214	42.60	pCi/l	4.6		Gamma
SS-8 Sp.	Y-12	06/25/05	Calcium	42.50	mg/L		0.03	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Chromium	U	µg/L		1	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Cobalt	U	µg/L		10	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Copper	U	µg/L		1	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Iron	189	µg/L		25	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Lead	U	µg/L		1	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Magnesium	14.20	mg/L		0.02	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Manganese	10.00	µg/L		5	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Mercury	U	µg/L		0.2	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Nickel	U	µg/L		10	Gen. Inorganics

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
SS-8 Sp.	Y-12	06/25/05	Potassium	0.90	mg/L		0.02	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Selenium	U	µg/L		2	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Sodium	1.70	mg/L		0.1	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Thallium	U	µg/L		2	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Vanadium	U	µg/L		1	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	Zinc	7	µg/L		1	Gen. Inorganics
SS-8 Sp.	Y-12	06/25/05	TCL Volatiles	U	µg/L			VOC
Substation Sp.	K-25	06/21/05	NO3&NO2 Nitrogen	0.22	mg/L		0.01	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Nitrogen, Total Kjeldahl	0.11	pH Units		0.1	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Phosphorus, Total	0.03	mg/L		0.004	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Nitrogen, Ammonia	0.03	mg/L		0.02	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Hardness, Total as CaCO3	171.00	mg/L		1.00	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Dissolved Residue	103.00	mg/L		10.00	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Arsenic	U	µg/L		1	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Beryllium	U	µg/L		1	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Cadmium	U	µg/L		1	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Calcium	37	mg/L		0.03	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Chromium	U	µg/L		1	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Cobalt	U	µg/L		10	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Copper	U	µg/L		1	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Iron	U	µg/L		25	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Lead	U	µg/L		1	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Magnesium	14.80	mg/L		0.02	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Manganese	U	µg/L		5	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Nickel	U	µg/L		10	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Potassium	U	mg/L		0.02	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Selenium	U	µg/L		2	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Sodium	U	mg/L		0.1	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Thallium	U	µg/L		2	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Zinc	7	µg/L		1	Gen. Inorganics
Substation Sp.	K-25	06/21/05	Carbon Disulfide	13.00	µg/L		5	VOC
Sycamore Sp	X-10	04/06/05	Gross Alpha	-1.80	pCi/l	3.0		Alpha
Sycamore Sp.	X-10	04/06/05	Gross Beta	16.80	pCi/l	3.6		Beta
Sycamore Sp.	X-10	04/06/05	Gamma	NDA	pCi/l			Gamma
Sycamore Sp.	X-10	04/06/05	Tc-99	-0.10	pCi/l	3.1		Gamma
Sycamore Sp. Dup.	X-10	04/06/05	Tc-99	0.60	pCi/l	3.1		Gamma
Sycamore Sp.	X-10	06/13/05	Gross Alpha		pCi/l			Alpha
Sycamore Sp.	X-10	06/13/05	Gross Beta		pCi/l			Beta
Sycamore Sp.	X-10	06/13/05	Gamma					Gamma
Sycamore Sp.	X-10	06/13/05	Arsenic	U	µg/L		1	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Beryllium	U	µg/L		1	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Cadmium	U	µg/L		1	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Calcium	147.00	mg/L		0.03	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Chromium	1.00	µg/L		1	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Cobalt	10.00	µg/L		10	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Copper	2.00	µg/L		1	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Iron	1580.00	µg/L		25	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Lead	3.00	µg/L		1	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Magnesium	7.90	mg/L		0.02	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Manganese	144.00	µg/L		5	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Nickel	18.00	µg/L		10	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Potassium	2.50	mg/L		0.02	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Selenium	U	µg/L		2	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Sodium	8.80	mg/L		0.1	Gen. Inorganics

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
Sycamore Sp.	X-10	06/13/05	Thallium	U	µg/L		2	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	Zinc	14.00	µg/L		1.00	Gen. Inorganics
Sycamore Sp.	X-10	06/13/05	H-3		pCi/l			Tritium
Sycamore Sp.	X-10	06/13/05	TCL Volatiles	U	µg/L			VOC
Sycamore Sp.	X-10	09/29/05	TCL Volatiles	U	µg/L			VOC
Tree Root Sp.	K-25	06/02/05	Gross Alpha	0.20	pCi/l	1.9		Alpha
Tree Root Sp.	K-25	06/02/05	Gross Beta	1.90	pCi/l	2.6		Beta
Tree Root Sp.	K-25	06/02/05	Gamma	NDA	pCi/l			Gamma
Tree Root Sp.	K-25	06/02/05	Arsenic	U	µg/L		1	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Beryllium	U	µg/L		1	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Cadmium	U	µg/L		1	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Calcium	25.3	mg/L		0.03	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Chromium	U	µg/L		1	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Copper	2.00	µg/L		1	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Iron	60	µg/L		25	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Lead	U	µg/L		1	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Manganese	U	µg/L		5	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Nickel	U	µg/L		10	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Selenium	U	mg/L		2	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Thallium	U	µg/L		2	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Zinc	7	µg/L		1	Gen. Inorganics
Tree Root Sp.	K-25	06/02/05	Tritium	0.00	pCi/l	169		H-3
Tree Root Sp.	K-25	06/02/05	Tc-99	-0.90	pCi/l	3.1		Tc-99
Tree Root Sp.	K-25	06/02/05	Carbon Disulfide	13.00	µg/L	L	5.00	VOC
USGS 10895	K-25	01/24/05	Gross Alpha	-0.40	pCi/l			Alpha
USGS 10895	K-25	01/24/05	Gross Beta	0.00	pCi/l			Beta
USGS 10895	K-25	01/24/05	Pb-214	93.20	pCi/l			Gamma
USGS 10895	K-25	01/24/05	Bi-214	127.40	pCi/l			Gamma
USGS 10895	K-25	01/24/05	Tritium		pCi/l			H-3
USGS 10895	K-25	01/24/05	Tc-99		pCi/l			Tc-99
USGS 10895	K-25	03/16/05	Gross Alpha	1.80	pCi/l	2		Alpha
USGS 10895	K-25	03/16/05	Gross Beta	0.70	pCi/l	2.6		Beta
USGS 10895	K-25	03/16/05	Pb-214	108.10	pCi/l	6		Gamma
USGS 10895	K-25	03/16/05	Bi-214	108.80	pCi/l	6.5		Gamma
USGS 10895	K-25	03/16/05	Tc-99	0.00	pCi/l	3.1		Tc-99
USGS 10895	K-25	03/16/05	Trichloroethene	3.20	µg/L		1.00	VOC
USGS 10895	K-25	07/12/05	Alkalinity	127.00	mg/L		10.00	Gen. Inorganics
USGS 10895	K-25	07/12/05	Chloride	2.00	mg/L		1.00	Gen. Inorganics
USGS 10895	K-25	07/12/05	Conductivity	279.00	umhos		0.5	Gen. Inorganics
USGS 10895	K-25	07/12/05	pH	7.40	pH units			Gen. Inorganics
USGS 10895	K-25	07/12/05	Dissolved Residue	147.00	mg/L		10.00	Gen. Inorganics
USGS 10895	K-25	07/12/05	Suspended Residue	U	mg/L		10.00	Gen. Inorganics
USGS 10895	K-25	07/12/05	Total Residue	172.00	mg/L		10.00	Gen. Inorganics
USGS 10895	K-25	07/12/05	Sulfate	3.00	mg/L		2	Gen. Inorganics
USGS 10895	K-25	07/12/05	NO3&NO2 Nitrogen	0.27	mg/L		0.10	Gen. Inorganics
USGS 10895	K-25	07/12/05	Nitrogen, ammonia	0.01	mg/L		0.02	Gen. Inorganics
USGS 10895	K-25	07/12/05	Nitrogen, Total Kjeldahl	0.26	mg/L		0.1	Gen. Inorganics
USGS 10895	K-25	07/12/05	Phosphorus, Total	U	mg/L		0.004	Gen. Inorganics
USGS 10895	K-25	07/12/05	Trichloroethene	6.92	µg/L		1.00	VOC
USGS 10895	K-25	08/12/05	Gross Alpha	0.40	pCi/l	2.3		Alpha
USGS 10895	K-25	08/12/05	Gross Beta	0.00	pCi/l	2.7		Beta
USGS 10895	K-25	08/12/05	Pb-214	47.50	pCi/l	4.3		Gamma
USGS 10895	K-25	08/12/05	Bi-214	49.00	pCi/l	4.9		Gamma
USGS 10895	K-25	08/12/05	Trichloroethene	4.98	µg/L		1.00	VOC

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
USGS 10895	K-25	09/08/05	Gross Alpha	0.50	pCi/l	2.6		Alpha
USGS 10895	K-25	09/08/05	Gross Beta	3.00	pCi/l	2.7		Beta
USGS 10895	K-25	09/08/05	Pb-214	59.30	pCi/l	5.3		Gamma
USGS 10895	K-25	09/08/05	Bi-214	70.20	pCi/l	5.7		Gamma
USGS 10895	K-25	09/08/05	Carbon Disulfide	12.30	µg/L		1.00	VOC
USGS 10895	K-25	09/08/05	Trichloroethene	5.77	µg/L		1.00	VOC
USGS 10895	K-25	10/11/05	Carbon Disulfide	8.15	µg/L		1.00	VOC
USGS 10895	K-25	10/11/05	Trichloroethene	6.89	µg/L		1.00	VOC
USGS 10895	K-25	11/16/05	TCL Volatiles	U	µg/L			VOC
USGS8900	K-25	03/30/05	Gross Alpha	1.20	pCi/l	2.6		Alpha
USGS8900	K-25	03/30/05	Gross Beta	0.90	pCi/l	2.4		Beta
USGS8900	K-25	03/30/05	Gamma	NDA	pCi/l			Gamma
USGS8900	K-25	03/30/05	Alkalinity	168.00	mg/L		10.00	Gen. Inorganics
USGS8900	K-25	03/30/05	Chloride	3.00			1.00	Gen. Inorganics
USGS8900	K-25	03/30/05	Conductivity	301.00			0.5	Gen. Inorganics
USGS8900	K-25	03/30/05	NO3&NO2 Nitrogen	0.16	mg/L		0.10	Gen. Inorganics
USGS8900	K-25	03/30/05	pH	7.30	pH units			Gen. Inorganics
USGS8900	K-25	03/30/05	Dissolved Residue	166.00	mg/L		10.00	Gen. Inorganics
USGS8900	K-25	03/30/05	Suspended Residue	21.00	mg/L		10.00	Gen. Inorganics
USGS8900	K-25	03/30/05	Total Residue	204.00	mg/L		10.00	Gen. Inorganics
USGS8900	K-25	03/30/05	Sulfate	4.00	mg/L		10	Gen. Inorganics
USGS8900	K-25	03/30/05	Nitrogen, ammonia	U	mg/L		0.02	Gen. Inorganics
USGS8900	K-25	03/30/05	Nitrogen, Total Kjeldahl	U	mg/L		0.1	Gen. Inorganics
USGS8900	K-25	03/30/05	Phosphorus, Total	U	mg/L		0.004	Gen. Inorganics
USGS8900	K-25	03/30/05	Arsenic	U	µg/L		1.00	Metals
USGS8900	K-25	03/30/05	Cadmium	U			1.00	Metals
USGS8900	K-25	03/30/05	Calcium	47.40	mg/L		2	Metals
USGS8900	K-25	03/30/05	Chromium	U			1	Metals
USGS8900	K-25	03/30/05	Cobalt	U			2.00	Metals
USGS8900	K-25	03/30/05	Iron	709.00	µg/L		25.00	Metals
USGS8900	K-25	03/30/05	Lead	U	µg/L		1.00	Metals
USGS8900	K-25	03/30/05	Magnesium	11.10	mg/L		0.02	Metals
USGS8900	K-25	03/30/05	Manganese	90.00	µg/L		5	Metals
USGS8900	K-25	03/30/05	Mercury		mg/L		0.02	Metals
USGS8900	K-25	03/30/05	Nickel	U	mg/L		10	Metals
USGS8900	K-25	03/30/05	Potassium	1.17	mg/L		0.3	Metals
USGS8900	K-25	03/30/05	Selenium	U	µg/L		2.00	Metals
USGS8900	K-25	03/30/05	Sodium	1.20	mg/L		0.10	Metals
USGS8900	K-25	03/30/05	Thallium	U	µg/L		2.00	Metals
USGS8900	K-25	03/30/05	Zinc	12.00	µg/L		1.00	Metals
USGS8900	K-25	03/30/05	Tc-99	1.80	pCi/l	3.1		Tc-99
USGS8900	K-25	03/30/05	TCL Volatiles	U	µg/L			VOC
Wild Sweet Potato Sp.	K-25	06/02/05	Gross Alpha	-0.10	pCi/l	1.3		Alpha
Wild Sweet Potato Sp.	K-25	06/02/05	Gross Beta	1.70	pCi/l	2.5		Beta
Wild Sweet Potato Sp.	K-25	06/02/05	Gamma	NDA	pCi/l			Gamma
Wild Sweet Potato Sp.	K-25	06/02/05	Arsenic	U	µg/L		1	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Beryllium	U	µg/L		1	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Cadmium	U	µg/L		1	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Calcium	6.53	mg/L		0.03	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Chromium	U	µg/L		1	Gen. Inorganics

Sample Location	ORR Site	Date	Parameter	Result	Units	Rad Error	Limit	Param. Group
Wild Sweet Potato Sp.	K-25	06/02/05	Copper	U	µg/L		1	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Iron	313	µg/L		25	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Lead	2.00	µg/L		1	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Manganese	89.00	µg/L		5	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Nickel	U	µg/L		10	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Selenium	U	mg/L		2	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Thallium	U	µg/L		2	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Zinc	10	µg/L		1	Gen. Inorganics
Wild Sweet Potato Sp.	K-25	06/02/05	Tritium	0.00	pCi/l	166		H-3
Wild Sweet Potato Sp.	K-25	06/02/05	Tc-99	0.60	pCi/l	3.1		Tc-99
Wild Sweet Potato Sp.	K-25	06/02/05	Carbon Disulfide	8.00	µg/L	2	5.00	VOC
Zboil Sp.	K-25	03/31/05	Gross Alpha	1.70	pCi/l	2.7		Alpha
Zboil Sp.	K-25	03/31/05	Gross Beta	4.10	pCi/l	2.7		Beta
Zboil Sp.	K-25	03/31/05	Gamma	NDA	pCi/l			Gamma
Zboil Sp.	K-25	03/31/05	Alkalinity	161.00	mg/L		10.00	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Chloride	4.00	mg/L		1.00	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Conductivity	297.00	mg/L	1	0.5	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	NO3&NO2 Nitrogen	0.19	mg/L		0.10	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	pH	7.50	pH Units			Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Dissolved Residue	169.00	mg/L		10.00	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Suspended Residue	72.00	mg/L		10.00	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Total Residue	238.00	mg/L		10.00	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Sulfate	4.00	mg/L		10	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Nitrogen, ammonia	U	mg/L		0.02	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Nitrogen, Total Kjeldahl	U	mg/L		0.1	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Phosphorus, Total	0.02	mg/L		0.004	Gen. Inorganics
Zboil Sp.	K-25	03/31/05	Arsenic	U	µg/L		1.00	Metals
Zboil Sp.	K-25	03/31/05	Cadmium	U			1.00	Metals
Zboil Sp.	K-25	03/31/05	Calcium	51.60	mg/L		2	Metals
Zboil Sp.	K-25	03/31/05	Chromium	U			1	Metals
Zboil Sp.	K-25	03/31/05	Cobalt	U			2.00	Metals
Zboil Sp.	K-25	03/31/05	Iron	544.00	µg/L		25.00	Metals
Zboil Sp.	K-25	03/31/05	Lead	U	mg/L		1.00	Metals
Zboil Sp.	K-25	03/31/05	Magnesium	11.20	mg/L		0.02	Metals
Zboil Sp.	K-25	03/31/05	Manganese	45.00	µg/L		5	Metals
Zboil Sp.	K-25	03/31/05	Mercury		mg/L		0.02	Metals
Zboil Sp.	K-25	03/31/05	Nickel	U	mg/L		10	Metals
Zboil Sp.	K-25	03/31/05	Potassium	1.31	mg/L		0.3	Metals
Zboil Sp.	K-25	03/31/05	Selenium	U	µg/L		2.00	Metals
Zboil Sp.	K-25	03/31/05	Sodium	2.00	mg/L		0.10	Metals
Zboil Sp.	K-25	03/31/05	Thallium	U	µg/L		2.00	Metals
Zboil Sp.	K-25	03/31/05	Zinc	17.00	µg/L		1.00	Metals
Zboil Sp.	K-25	03/31/05	Tc-99	0.00	pCi/l	3.1		Tc-99
Zboil Sp.	K-25	03/31/05	Carbon Disulfide	7.00	µg/L		L	VOC

CHAPTER 5 RADIOLOGICAL MONITORING

Ambient Radiation Monitoring on the Oak Ridge Reservation Using Environmental Dosimetry (RMO)

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Abstract

The Tennessee Department of Environment and Conservation began monitoring ambient radiation levels on the Oak Ridge Reservation in 1995. The program provides conservative estimates of the dose to members of the public from exposure to gamma and neutron radiation attributable to Department of Energy activities on the reservation and baseline values for measuring the need and effectiveness of remedial activities. In this effort, environmental dosimeters have been placed at selected locations on and near the reservation. Results from the dosimeters are compared to background values and the state dose limit for members of the public. In 2005, the doses reported for locations monitored off the reservation were all at levels below the primary dose limit. There was also an overall decrease, compared to previous years, in the frequency and magnitude of doses reported above the primary dose limit for sites on the reservation considered potentially accessible to the public. As in the past, doses above the limit were relatively common at locations located in access restricted areas of the reservation.

Introduction

Radiation is emitted by various radionuclides that have been produced, stored, and disposed of on the Oak Ridge Reservation (ORR). As a consequence of past activities, both radioactive and toxic wastes contaminate many of the ORR facilities and surrounding environment. In order to assess the risks posed by radioactive contaminants, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division began monitoring ambient radiation levels on and in the vicinity of the ORR in 1995. In this effort, environmental dosimeters are used to measure the external radiation dose at selected monitoring stations on and in the vicinity of the ORR. The program provides:

- conservative estimates of the potential dose to members of the public from exposure to gamma radiation;
- baseline values used to assess the need and effectiveness of remedial actions;
- information necessary to establish trends in gamma radiation emissions;
- information relative to the unplanned release of radioactive contaminants on the ORR.

Methods and Materials

The dosimeters used in the program are obtained from Landauer, Inc., of Glenwood, Illinois. Each of the dosimeters use an aluminum oxide photon detector to measure the dose from gamma radiation (minimum reporting value = 1 mrem). At locations where a potential for the release of neutron radiation exists, the dosimeters also contain an allyl diglycol carbonate based neutron detector (minimum reporting value = 10 mrem). Dosimeters that contain the photon detectors alone are collected quarterly and sent to Landauer for processing. Dosimeters that contain both photon and neutron detectors are collected and processed semi-annually (to allow more precise neutron measurements).

To account for exposures received in transit, control dosimeters are provided with each shipment of dosimeters received from the Landauer Company. These dosimeters are stored in a lead container at the division's offices during the monitoring period and returned to Landauer for processing with the associated field deployed dosimeters. The vender subtracts the result for the control dosimeter (which should reflect exposures received in transport/storage) from the dose for the field deployed dosimeters prior to reporting the data.*

As the quarterly data are received from the vender, staff review the results and compile a quarterly report, which is distributed to DOE and other interested parties. At the end of the year, the quarterly results are summed for each location and the resultant annual dose compared to background values and the state's primary dose limit for members of the public (100 mrem/year above background concentrations and medical applications). Each year, a report of the results and findings are compiled and presented in the division's Annual Environmental Monitoring Report.

Monitoring stations in the program include: background locations, residential areas, locations on the ORR potentially accessible to the public, and sites subject to or undergoing remediation. The approximate locations of the monitoring stations, along with the 2005 annual dose for each site, are depicted in Figure A1 in the appendix.

Results and Discussion

It should be understood, the Atomic Energy Act exempts DOE from outside regulation of radiological materials at its facilities, but requires DOE to manage these materials in a manner protective of the public health and the environment. Since access to the reservation has been predominately restricted to employees of DOE or their contractors in the past, locations within the fenced areas of the reservation have traditionally been viewed as inaccessible to the general public. With the reindustrialization and revitalization of portions of the reservation, there has been an influx of workers employed by businesses not directly associated with DOE operations. If these individuals are considered members of the general public, several of the sites within the boundaries of the ORR become problematic.

State regulations define a member of the public as *any* individual, except those receiving an occupational dose of radiation. In the state regulations, an occupational dose refers to the radiation dose received by an individual employed to perform duties that involve exposures to radiation. The regulations go on to limit the dose to members of the public to 100 mrem/year (above background and medical applications) and the release of radiation to unrestricted areas to a dose of two mrem in any one-hour period. In this context, a restricted area is defined as an area with access limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

**Note:* Prior to 2005, control dosimeters were stored unshielded at the division's offices during the monitoring period, which, in effect, incorporated background exposures for the monitoring interval into the control dose subtracted from the field dosimeter results. To comply with associated protocol in ANSI N545-1975, staff began in 2005 to store the control dosimeters in a lead container during the monitoring period. Since the lead container shields the control dosimeter from background radiation, a background measurement is no longer included in the control dose or subtracted from the dose reported for the monitored sites. To evaluate the data, the doses from several background locations (areas that should be unaffected by DOE operations) are included in the data set (e.g., TDEC offices, Norris Dam, Fort Loudoun Dam).

The dose of radiation an individual receives at any given location is dependent on the intensity and the duration of the exposure. For example, an individual standing at a site where the dose rate is one mrem/hour would receive a dose of two mrem, if he stayed at the same spot for two hours. If he or she were exposed to the same level of radiation for eight hours a day for the approximately 220 working days in a year (1,760 hours), the individual would receive a dose of 1,760 mrem in that year. It should be understood, the doses reported in the division's Ambient Radiation Monitoring Programs are based on the exposure an individual would receive if he or she remained at the monitoring station twenty-four hours a day for one year (8,760 hours). Since this is very unlikely to be the actual case, the doses reported should be viewed as conservative estimates of the maximum dose an individual would receive at each location.

The monitoring locations and associated results for the program can be roughly organized into three categories: (1) stations located off the ORR; (2) sites on the ORR that are, to some degree, accessible to the public; and (3) locations within restricted areas of the reservation. When reviewing the data, it should be understood the doses reported for the program include background radiation associated with the site, which would not be included in assessing the dose limit. For comparisons, the annual doses reported for Norris Dam (31 mrem/year), Fort Loudoun Dam (25 mrem/year), and the division's office on Emory Valley Road in Oak Ridge (22 mrem/year) should be representative of areas unaffected by DOE activities on the ORR.

<u>Stations off the ORR</u>

The doses reported for monitoring stations off the reservation (e.g., residential areas) were all well below the 100 mrem dose limit for members of the public and occasionally below the detection capabilities of the environmental dosimeters (1 mrem).

<u>Stations Potentially Accessible to the Public</u>

Overall, the doses reported at sites on the ORR considered potentially accessible to the public declined in frequency and magnitude in 2005, when compared to previous years. The most significant decreases were achieved at ETTP's uranium hexafluoride (UF_6) cylinder storage yards. In the past, the doses measured at these facilities have consistently been among the highest results reported in the program. In addition, the rusted and deteriorating cylinders pose a risk for the release of both radioactive and toxic materials. To remedy this condition, the state and DOE entered into a consent order in 1999 requiring the removal of the depleted uranium hexafluoride cylinders from ETTP by December 31, 2009.

In 2004, DOE began shipping ORR UF_6 cylinders to the Portsmouth Gaseous Diffusion Plant, where the material is to be converted into a form more suitable for use and/or disposal. As a consequence, the doses of radiation associated with the cylinders significantly decreased in 2005. These doses ranged from background levels at the K-1066-B Yard (where all cylinders have been removed) to 1,462 mrem/year at the K-1066-K Yard, (where the dose fell more than 80% in the second semester of 2005). For comparison, the doses reported for the cylinder yards in 2004 ranged from 47 to 4,044 mrem/year. The doses reported for the storage yards are expected to continue to decrease as the remaining cylinders are moved to the Portsmouth site. A more comprehensive assessment of the cylinder storage yards can be found in *Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride (UF6) Cylinder Yards at the K-25 (East Tennessee Technology Park) Site.*

In addition to the UF6 cylinder yards, the dose measurements taken at the K-1420 Decontamination and Uranium Recovery Facility at ETTP have historically exhibited results above the primary dose limit. One of the more contaminated facilities at the site, the building was constructed in 1954 to house decontamination and uranium recovery operations, including the disassembly and chemical decontamination of gaseous diffusion equipment. In 1999, DOE's Reindustrialization Program contracted with a private firm to decontaminate the facility, in exchange for the use of space in the building after the project was completed. The effort was abandoned following a contract dispute and the facility was subsequently scheduled for demolition, which is currently underway. The dose reported for 2005 (716 mrem) was above the primary dose limit, but should decline with the completion of the action.

The situation at ORNL is somewhat different: land adjacent to the main campus has been deeded to organizations outside of DOE; buildings have been constructed using private funds; and facilities are being occupied by non-DOE contractors (2003, ORAU). Access to the site is controlled for security purposes, but admittance is allowed with the appropriate visitor's pass. Within the access controlled area, sites have been designated as radiation areas for safety, but the doses measured at the boundary of some of these areas have exceeded the primary dose limit and approached the state's limit for the dose to an unrestricted area. Like ETTP, there was a decrease at ORNL in 2005 in the number of sites considered potentially accessible to the public that exceeded the primary dose limit. The decline can largely be attributed to the completion of remedial activities at the surface impoundments and the removal of wastes generated by the Surface Impoundment and Corehole 8 Remedial Actions. Monitoring locations potentially accessible to the public reporting doses greater than 100 mrem/year at ORNL included: the White Oak Creek Weir at Lagoon Road (305 mrem), the ORNL Molten Salt Reactor (796 mrem), and a hot spot found on Haw Ridge (225 mrem).

Stations within Restricted Areas of the Reservation

While conditions could change, other sites monitored that reported results appreciably above the primary dose limit are located within restricted areas of the reservation. While it is beyond the scope of this report to address each of these sites individually, several merit comment.

As in past years, the highest dose reported for 2005 (14,456 mrem) was for station 32, a tulip poplar tree in ORNL's "Cesium Forest." Nearby, a dose of 577 mrem was reported for Station 33, which is also located in the Cesium Forest. Both of these sites appear to be associated with a 1962 study that injected a group of trees at the location with 360 millicuries of cesium-137 to investigate the isotope's behavior in a forest ecosystem (Witkamp, 1964).

Other sites in ORNL restricted areas with results greater than the primary dose limit in 2005 were Station 35 (761 mrem) near the confluence of White Oak Creek and Melton Branch and Station 87 (402 mrem) at the SWASA 5 disposal area. These sites appear unlikely to be accessed by a member of the public under current conditions and all except Station 32 in the Cesium Forest fall below the limits for an adult worker monitored with personnel dosimetry (5000 mrem/year).

Conclusion

Overall, the radiation doses measured in the Environmental Dosimetry Program decreased in 2005. To a large degree, this decrease can be attributed to site remediation (e.g., the Surface Impoundment Operable Unit), the removal of stored remedial wastes (e.g., contaminated soils and sediments from the Surface Impoundments and Corehole 8 remedial projects), and the transfer of uranium hexafluoride cylinders from ETTP to the Portsmouth Gaseous Diffusion Plant. No monitoring stations off the ORR exceeded the state's Primary Dose Limit for Members of the Public. While less frequent than in past years, several sites considered potentially assessable to the public did exceed the dose limit. These locations included: the K-1066-K UF_6 Cylinder Storage Yard (ETTP), the K-1066-E UF_6 Storage Yard (ETTP), the K-1420 Decontamination and Uranium Recovery Facility (ETTP), White Oak Creek Weir at Lagoon Road (ORNL), the Molten Salt Reactor (ORNL), and a hot spot found on Haw Ridge (ORNL). As in the past, results above the public dose limit were common at locations in restricted areas of the reservation.

References

American National Standards Institute, 1975. *ANSI N545-1975, Appendix B.*

Oak Ridge Associated Universities (ORAU), 2003. *ORAU Team NIOSH Dose Reconstruction Project.* http://www.cdc.gov/niosh/ocas/pdfs/tbd/ornl2.pdf. ORAUT-TKBS-0012-2. November 2003.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the Department of Energy and the state of Tennessee.* Oak Ridge, Tennessee. 2001.

Tennessee Department of Environment and Conservation, 2004. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division Environmental Monitoring Plan January through December 2005.* December 2004. Oak Ridge, Tennessee.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

U.S. Department of Energy, 1998. *Engineering Evaluation/Cost Analysis for the Old Hydrofracture Facility Tanks and Impoundment, Oak Ridge National Laboratory, Oak Ridge, Tennessee.* DOE/OR/02-1706&D1. April 1998.

U.S. Department of Energy, 1999. *1999 Remedial Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge Tennessee*. DOE/OR-1790&D1. February 1999.

Witkamp M., and M.L. Frank, 1964. *First Year of Movement, Distribution and Availability of* Cs^{137} *in the Forest Floor under Tagged Tulip Poplars*. *Radiation Botany*, Vol. 4 pp. 485-495. 1964.

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APPENDIX: LOCATION MAP AND TABLE OF RESULTS FROM TDEC MONITORING ON THE OAK RIDGE RESERVATION USING ENVIRONMENTAL DOSIMETERS

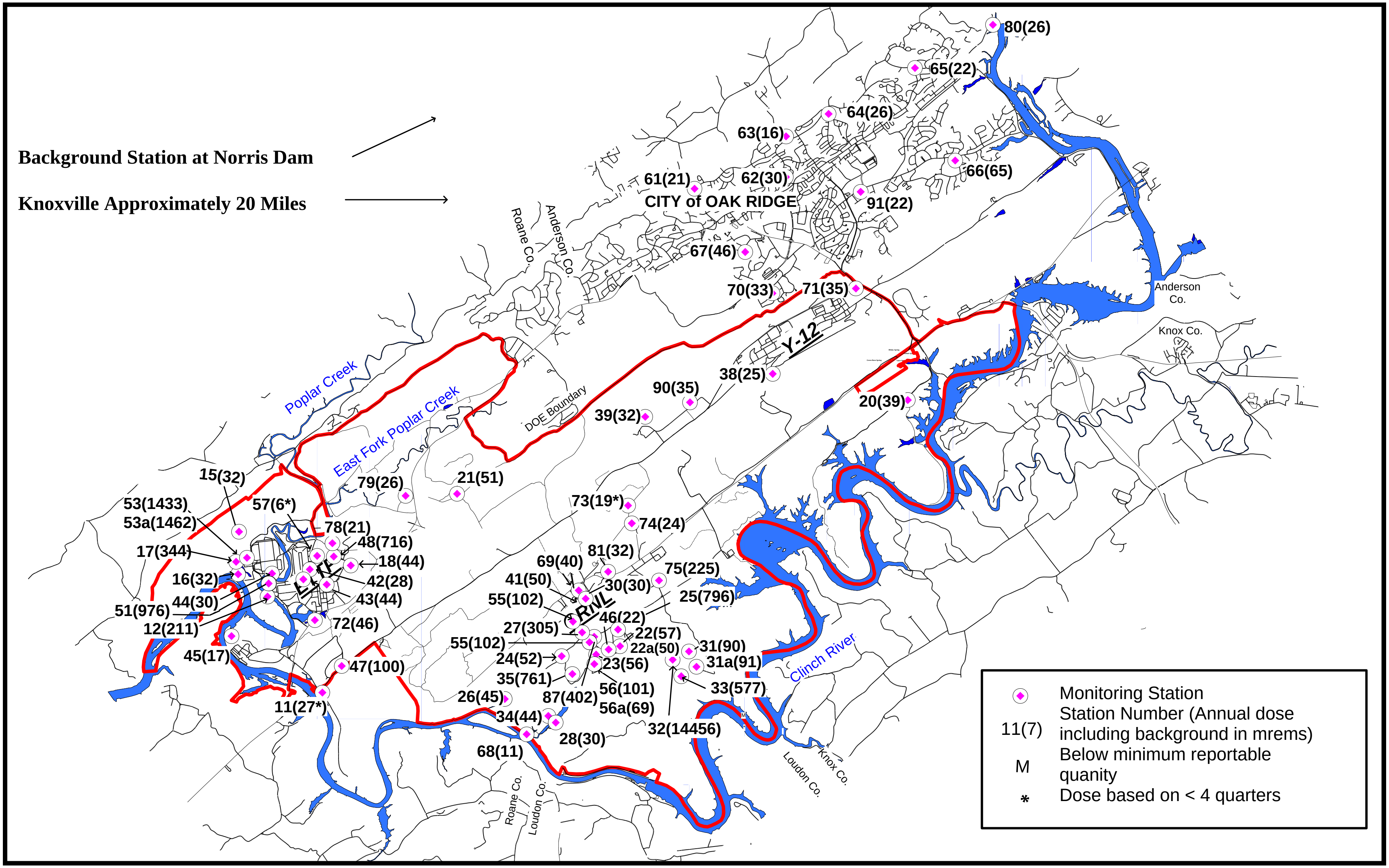

Figure A1: Approximate Location TDEC Environmental Dosimeters on the Oak Ridge Reservation

Table A1: 2005 Results from TDEC monitoring on the Oak Ridge Reservation using Environmental Dosimeters

Station # (Dosimeter)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly & neutron dosimeters are reported semi-annually*	Type of Radiation	Dose Reported for 2005 in mrem M = Below Minimum Reportable Quantity				2005 Total Dose
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	
9. (OSL)	Off-site Norris Dam Air Monitoring Station (Background)	Gamma	13	2	9	7	31
11. (OSL)	ETTP Grassy Creek Embayment on the Clinch River	Gamma	15	Absent	5	7	27*
12. (Neutron)	ETTP UF_6 Cylinder Storage Yard K-1066-E	Neutron	M		M		211
		Gamma	116		95		
15. (OSL)	ETTP K-1070-A Burial Ground	Gamma	16	3	5	8	32
16. (OSL)	ETTP K-901 Pond	Gamma	13	12	3	4	32
17. (Neutron)	ETTP K-1066-K UF_6 Cylinder Yard (near K-895)	Neutron	M		M		344
		Gamma	295		49		
18. (OSL)	ETTP TSCA on fence across from Tank Farm	Gamma	19	7	7	11	44
20. (OSL)	ORNL Freels Bend Entrance	Gamma	15	5	10	9	39
21. (OSL)	ETTP White Wing Scrap Yard	Gamma	15	10	14	12	51
22. (OSL)	ORNL High Flux Isotope Reactor	Gamma	23	9	13	12	57
22a. (OSL)	ORNL High Flux Isotope Reactor (duplicate)	Gamma	21	5	14	10	50
23. (OSL)	ORNL Solid Waste Storage Area 5	Gamma	18	8	15	15	56
24. (OSL)	ORNL Building X-7819	Gamma	18	10	13	11	52
25. (OSL)	ORNL Molten Salt Reactor Experiment	Gamma	205	177	217	197	796
26. (OSL)	ORNL Cesium Fields	Gamma	17	5	14	9	45
27. (OSL)	ORNL White Oak Creek Weir @ Lagoon Rd	Gamma	74	62	83	86	305
28. (OSL)	ORNL White Oak Dam	Gamma	15	4	7	4	30
30. (OSL)	ORNL X-3513 Impoundment	Gamma	14	2	6	8	30
31. (OSL)	ORNL @ Cesium Forest boundary	Gamma	30	16	19	25	90
31a. (OSL)	ORNL @ Cesium Forest boundary (duplicate)	Gamma	28	18	23	22	91
32. (OSL)	ORNL Cesium Forest on tree	Gamma	2,842	3,173	3,946	4,495	14,456
33. (OSL)	ORNL Cesium Forest Satellite Plot	Gamma	146	136	145	150	577
34. (OSL)	ORNL SWSA 6 on fence @ Highway 95	Gamma	19	8	9	8	44
35. (OSL)	ORNL confluence of White Oak Creek & Melton Branch	Gamma	210	163	187	201	761
38. (OSL)	Y-12 Uranium Oxide Storage Vaults	Gamma	15	1	4	5	25
39. (OSL)	Y-12 @ back side of Walk In Pits	Gamma	13	6	8	5	32
41. (OSL)	ORNL North Tank Farm	Gamma	19	10	9	12	50

Table A1: 2005 Results from TDEC monitoring on the Oak Ridge Reservation using Environmental Dosimeters (Continued)

Station # (Dosimeter)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly & neutron dosimeters are reported semi-annually*	Type of Radiation	Dose Reported for 2005 in mrem M = Below Minimum Reportable Quantity				2005 Total Dose
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	
42. (OSL)	ETTP east side of the K-1401 Building	Gamma	13	2	6	7	28
43. (OSL)	ETTP west side of the K-1401 Building	Gamma	18	6	11	9	44
44. (OSL)	ETTP K-25 Building	Gamma	16	5	6	3	30
45. (OSL)	ETTP K-770 Scrap Yard	Gamma	11	1	1	4	17
46. (OSL)	ORNL Homogeneous Reactor Experiment Site	Gamma	11	4	4	3	22
47. (OSL)	Y-12 Bear Creek Road ~ 2800 feet from Clinch River	Gamma	32	18	23	27	100
48. (OSL)	ETTP K-1420 Building	Gamma	170	199	144	203	716
51. (Neutron)	ETTP north side of the K-1066-E UF_6 Cylinder	Neutron	M		M		976
	Storage Yard	Gamma	663		313		
53. (Neutron)	ETTP southwest corner of the K-1066-K UF_6 Cylinder	Neutron	M		M		1,433
	Storage Yard	Gamma	1,189		244		
53a. (Neutron)	ETTP southwest corner of the K-1066-K UF_6 Cylinder	Neutron	M		M		1,462
	Storage Yard (duplicate)	Gamma	1,253		209		
55. (OSL)	ORNL SWSA 5 True Waste Trench	Gamma	35	13	25	29	102
56. (OSL)	ORNL Old Hydrofracture Pond	Gamma	13	27	33	28	101
56a. (Neutron)	ORNL Old Hydrofracture Pond (duplicate)	Neutron	M		M		69
		Gamma	11		58		
57. (OSL)	ETTP UF_6 Cylinder Storage Yard K-1066-B	Gamma	Absent	1	2	3	6*
61. (OSL)	Off site Temp. #14 Outer & Illinois Ave	Gamma	12	1	4	4	21
62. (OSL)	Off site Temp. #15 East Pawley	Gamma	13	4	7	6	30
63. (OSL)	Off site Temp. #16 Key Springs Road	Gamma	11	M	3	2	16
64. (OSL)	Off site Temp. #17 Cedar Hill Greenway	Gamma	13	2	7	4	26
65. (OSL)	Off site Temp. #18 California Ave.	Gamma	14	1	4	3	22
66. (OSL)	Off site Temp. #19 Emory Valley Greenway	Gamma	25	11	16	13	65
67. (OSL)	Off site Temp. #20 West Vanderbilt	Gamma	18	6	12	10	46
68. (OSL)	ORNL White Oak Creek @ Coffer Dam	Gamma	9	M	1	1	11
69. (OSL)	ORNL Graphite Reactor	Gamma	19	6	10	5	40
70. (OSL)	Off site Scarboro Perimeter Air Monitoring Station	Gamma	14	6	5	8	33
71. (OSL)	Y-12 East Perimeter Air Monitoring Station	Gamma	15	5	9	6	35
72. (OSL)	ETTP Visitors Center	Gamma	15	10	12	9	46

Table A1: 2005 Results from TDEC monitoring on the Oak Ridge Reservation using Environmental Dosimeters (Continued)

Station # (Dosimeter)	Location *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly & neutron dosimeters are reported semi-annually*	Type of Radiation	Dose Reported for 2005 in mrem M = Below Minimum Reportable Quantity				2005 Total Dose
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	
73. (OSL)	ORNL Temp. #3: Spallation Neutron Source (north side)	Gamma	14	Absent	Absent	5	19*
74. (OSL)	ORNL Temp. #4: Spallation Neutron Source (south side)	Gamma	15	M	5	4	24
75. (OSL)	ORNL Temp #5: hot spot on Haw Ridge	Gamma	56	49	57	63	225
78. (OSL)	ETTP Temp. #11: ED3 Quarry at Blair Road	Gamma	15	1	3	2	21
79. (OSL)	ETTP Temp. # 12: ED1 on pole	Gamma	11	4	6	5	26
80. (OSL)	Off site Temp. #13: Elza Gate	Gamma	13	3	5	5	26
81. (OSL)	ORNL visitors center	Gamma	14	3	6	9	32
86. (OSL)	Off site Fort Loudoun Dam Air Monitoring Station (Background)	Gamma	12	2	6	5	25
86a. (Neutron)	Off site Loudoun Dam Air Monitoring Station (Background)	Neutron	M		M		25
		Gamma	10		15		
87. (Neutron)	ORNL SWSA 5	Neutron	M		M		402
		Gamma	195		207		
90. (OSL)	EMWMF	Gamma	16	5	6	8	35
91. (OSL)	TDEC DOE-O office (Background)	Gamma	14	1	3	4	22

M = below minimum reportable quantity (1 mrem for gamma, 10 mrem for thermal neutrons)
Absent = the dosimeter was not found at the time of collection
*= The dose reported for this station was based on the sum of less than four quarters of data.

Notes:
-Two types of dosimeters are used in the program, optically stimulated luminescent dosimeters (OSLs) and neutron dosimeters. The OSLs measure the dose from gamma radiation, which is considered sufficient for most of the monitoring stations. The neutron dosimeters, which have been placed at selected locations, measure the dose from neutrons in addition to the gamma radiation. The OSLs are reported quarterly; the neutron dosimeters are reported semi-annually. At the locations where the neutron dosimeters have been deployed, the total dose is the sum of the doses reported for neutron and gamma radiation.
-To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office and returned to the vender for processing along with the associated field deployed dosimeters. The dose reported for the control dosimeter is subtracted from the dose reported for each field deployed dosimeter. Beginning in 2005, background derived from the dose at the division's offices is no longer subtracted from the results for the individual sites. As a consequence, data reported for 2005 can be expected to be slightly higher than in past years
-The primary dose limit for members of the public specified in both DOE Orders and 10 CFR Part 20 (Standards for Protection Against Radiation) is 100 mrem/year total effective dose equivalent exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

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CHAPTER 5 RADIOLOGICAL MONITORING

Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride (UF_6) Cylinder Yards at the East Tennessee Technology Park

Principle Author: Robert Storms

Abstract

The Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) in cooperation with the Department of Energy (DOE) and the Bechtel Jacobs Company is conducting a radiation dose rate survey of the East Tennessee Technology Park's (ETTP) Uranium Hexafluoride (UF_6) cylinder storage yards. Dose rate measurements are taken at the Perimeter fence lines using Landauer® Luxel® optically stimulated luminescence (Aluminum Oxide) dosimeters. Monitoring of ambient gamma levels at the UF_6 cylinder storage yards began in April 1999 and has continued to date. The data gathered is being used to determine if areas monitored have exceeded state and/or federal regulatory limits for exposure to members of the public. This data is also being used to determine if environmental concerns are warranted and what, if any, remediation actions are necessary before this property is free released and/or prior to occupation by companies during the planned reindustrialization of the ETTP site. In this study period from January 2005 to January 2006, dose rates in excess of the 100-mrem/yr. (the state and federal exposure limit) were observed at three of the four monitored cylinder yards. The K-1066 B Yard was taken out of the program at the end of 2004 as it was emptied and continued monitoring did not show readings above background. Subsequently, the K-1066 K Yard will be dropped after this year due to the same circumstances. Specific location data has been obtained for all stations with the use of GPS instrumentation. This specific location data, along with its corresponding radiological data, will be incorporated into the MapInfo computer program. With this, the user has the ability to locate an individual monitoring point and view its radiological history.

Introduction

During the development and operation of the gaseous diffusion uranium enrichment process, containers, support equipment, and support facilities were designed, constructed, and used to store, transport, and process the depleted UF_6. After a significant inventory was produced, outdoor storage facilities (i.e., cylinder yards) evolved. Today, the Bechtel Jacobs Company operates the six ETTP UF_6 cylinder storage yards for the DOE. They are used for the temporary and long-term storage of UF_6 cylinders. The goal of the DOE-O UF_6 cylinder yard dose assessment program is to evaluate the level at which the public is protected from radiation doses emitted from the cylinder yards. This is especially important since DOE's mission is the continual transformation of ETTP into a commercial industrial park.

Materials and Methods

Dosimeters measure the dose from exposure to gamma radiation over time. The division's cylinder yard monitoring is performed using one type of dosimeter, Aluminum Oxide. They are obtained from Landauer®, Inc., Glenwood, Illinois. Aluminum Oxide dosimeters (minimum reporting value of 1 mrem) are generally placed in areas where exposures are expected to be significantly higher than background. The dosimeters are collected by division staff and shipped to Landauer® for processing. To account for exposures that may be received in transit or storage, control dosimeters are included in each shipment from the Landauer® Company. The control dosimeters are stored in a shielded container at the division office, and returned to Landauer® with the field-deployed dosimeters for processing. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division offices (761 Emory Valley Road, Oak Ridge, Tennessee) is subtracted from the exposure reported for the field deployed dosimeters by Landauer. Annually, the quarterly exposures (minus the exposure obtained from the control dosimeter) are summed for each location. The resultant annual dose is compared to the state and DOE primary dose limit for members of the public (100 mrem/yr exposure).

Discussion and Results

The division's Ambient Gamma Radiation Monitoring program has determined that during 2005, there was an elevated exposure potential to the public at three of the four monitored cylinder yards. With the removal of all cylinders from the K-1066 K-yard, and subsequent monitoring showing no elevation above background, this will lessen the potential elevated dose to the public to the K-1066 E and K-1066 J-yard. 2005 monitoring results at these yards, the total adjusted accumulated annual dose, as measured by dosimeter, has ranged from a low of 9 mrem at the K-1066-J yard to a high of 4165 mrem at the K-1066-E yard. The high value is almost half of the high reading from 2004. Within this range, there are numerous elevated data points that are shown in tables 1-5. These results are compared with the state/DOE primary dose limit for members of the public (100 mrem/yr total exposure). The mapping and recording of dose rate data will ensure that workers and non-DOE workers under ETTP's reindustrialization plan and the public will be knowledgeable of and protected from the cylinder yard's radiation sources.

The following ETTP cylinder yards were under the dosimeter project for 2005:

K-1066-K, K-1066-E, K-1066-J, K-1066-L

Current and future plans by ETTP to prepare cylinders for yard to yard movement and off-site shipment will necessitate "shuffling" cylinders between various yards. Due to this activity, there have been some wide variances in the dosimeter readings from quarter to quarter. These have all been checked and correlated with redistribution activity of the cylinders. During 2005, six dosimeters were reallocated around the K-1066-J yard so as to better represent the yard due to recent tank movements and to cover work trailers moved near an outer fence.

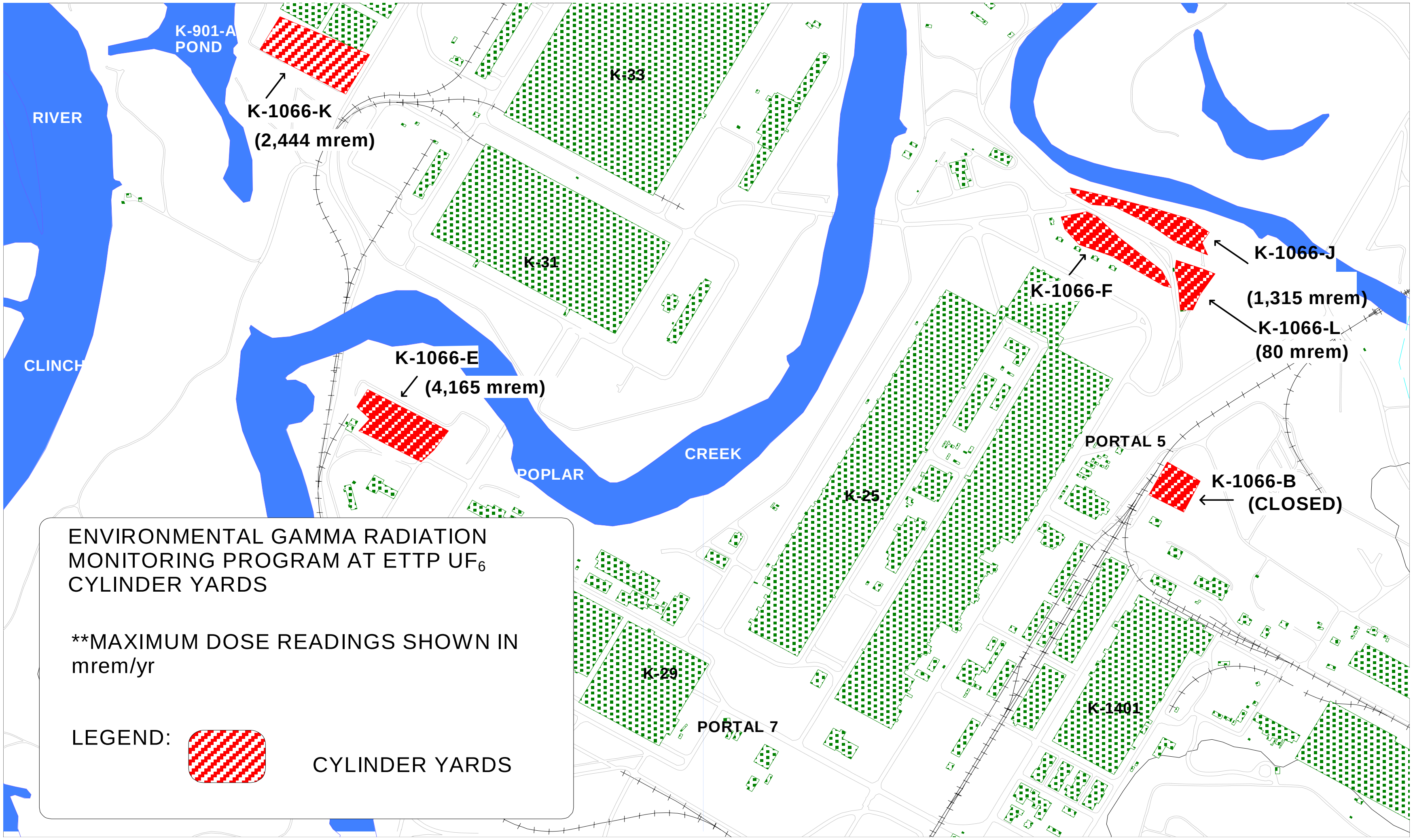


Figure 1: Map of ETTP Showing Location of Cylinder Yards

Table 1: Results from Dosimeters Deployed at ETTP UF_6 Cylinder Yards

K-1066-K Yard						
	Period 1 (01/21/05 - 04/21/05) (91 Day Exposure)	**Period 2** (04/22/05 - 07/21/05) (91 Day Exposure)	**Period 3** (07/22/05 - 10/17/05) (88 Day Exposure)	**Period 4** (10/18/05- 01/24/06) (99 Day Exposure)	Total Accumulated Dose Equivalent: 369 days	Total Adjusted Dose to 365 days
Dosimeter Number	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	Dosimeter Reading (mrem)	mrem	mrem
1	41	19	5	7	72	71
2	153	81	13	9	256	253
3	360	341	89	7	797	788
4	635	300	46	6	987	976
5	198	122	20	5	345	341
6	414	413	94	8	929	919
7	414	276	107	5	802	793
8	500	397	121	2	1020	1009
9	539	398	141	M	1078	1066
10	236	127	8	3	374	370
11	163	101	6	5	275	272
12	407	252	11	4	674	667
13	1422	1013	33	3	2471	2444
14	1646	587	108	8	2349	2323
15	1291	558	46	4	1899	1878
16	945	398	12	2	1357	1342
17	484	173	10	2	669	662
18	988	326	14	2	1330	1315
19	1637	346	15	4	2002	1980
20	1251	45	10	3	1309	1295
21	141	33	8	5	187	185
22	347	226	123	6	702	694

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/year.
* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters by Landauer.

M= Below minimum reportable quantity.

Table 2: Results from Dosimeters Deployed at ETTP UF_6 Cylinder Yards

K1066-E Yard						
	Period 1 (01/21/05 - 04/25/05) (95 Day Exposure)	**Period 2** (04/26/05 - 07/22/05) (88 Day Exposure)	**Period 3** (07/23/05 - 10/19/05) (89 Day Exposure)	**Period 4** (10/20/05 – 01/25/06) (98 Day Exposure)	Total Accumulated Dose Equivalent: 370 days	Total Adjusted Dose to 365 days
Dosimeter Number	**Dosimeter Reading (mrem)**	**Dosimeter Reading (mrem)**	**Dosimeter Reading (mrem)**	**Dosimeter Reading (mrem)**	**mrem**	**mrem**
23	189	137	397	297	1020	1006
24	418	318	400	364	1500	1479
25	239	153	103	84	579	571
26	107	80	181	218	586	578
27	1563	1214	961	486	4224	4165
28	1269	1027	678	301	3275	3229
29	1108	1136	789	853	3886	3832
30	1080	1000	668	503	3251	3205
31	466	777	879	988	3110	3066
32	529	447	1019	1113	3108	3064
33	201	147	68	32	448	442
34	58	97	139	57	351	346
35	82	96	172	54	404	398
36	141	132	163	140	576	568
37	206	179	206	156	747	737
38	170	153	176	112	611	602
39	140	110	177	143	570	562
76	52	48	36	24	160	158
77	66	58	54	52	230	227
78	55	45	53	48	201	198
79	292	282	195	97	866	854
80	323	354	237	136	1050	1035
81	388	287	203	166	1044	1029
82	314	222	203	222	961	948
83	156	140	153	160	609	600
84	121	133	118	128	500	493

* The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/year.

* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters by Landauer.

Table 3: Results from Dosimeters Deployed at ETTP UF_6 Cylinder Yards

K1066-J Yard						
	Period 1 (01/21/05 - 04/25/05) (95 Day Exposure)	**Period 2** (04/26/05 - 07/22/05) (88 Day Exposure)	**Period 3** (07/23/05 - 10/19/05) (89 Day Exposure)	**Period 4** (10/20/05 - 01/25/06) (98 Day Exposure)	Total Accumulated Dose Equivalent: 370 days	Total Adjusted Dose to 365 days
Dosimeter Number	**Dosimeter Reading (mrem)**	**Dosimeter Reading (mrem)**	**Dosimeter Reading (mrem)**	**Dosimeter Reading (mrem)**	**mrem**	**mrem**
40	6	5	6	4	21	21
41	3	M	2	4	9	9
42	6	2	4	2	14	14
43	2	4	6	6	18	18
44	4	4	5	4	17	17
45	M	7	5	7	19	19
46	3	6	5	7	21	21
47	4	3	4	6	17	17
48	5	4	6	6	21	21
49	3	6	8	5	22	22
50	15	18	19	22	74	73
51	24	20	24	22	90	89
52	23	12	10	12	57	56
53	2	6	8	11	27	27
54	15	22	32	21	90	89
55	23	17	7	9	56	55
56	N/A	50	48	92	190	187
57	N/A	234	246	120	600	592
58	N/A	590	738	6	1334	1315
85	M	3	3	5	11	11
86	1	5	3	4	13	13
87	7	4	4	7	22	22
88	5	5	8	9	27	27
89	6	7	7	7	27	27
90	2	7	4	8	21	21
91	7	8	7	10	32	32
92	4	5	5	6	20	20
93	6	8	6	8	28	28
94	8	9	7	7	31	31
95	7	6	7	9	29	29

* The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/year.
* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters by Landauer.M= Below minimum reportable quantity.

Table 4: Results from Dosimeters Deployed at ETTP UF_6 Cylinder Yards

K1066-L Yard						
	Period 1 (01/21/05 - 04/25/05) (95 Day Exposure)	**Period 2** (04/26/05 - 07/22/05) (88 Day Exposure)	**Period 3** (07/23/05 - 10/19/05) (89 Day Exposure)	**Period 4** (10/20/05- 01/25/06) (98 Day Exposure)	Total Accumulated Dose Equivalent: 370 days	Total Adjusted Dose to 365 days
Dosimeter Number	**Dosimeter Reading (mrem)**	**Dosimeter Reading (mrem)**	**Dosimeter Reading (mrem)**	**Dosimeter Reading (mrem)**	**mrem**	**mrem**
68	6	6	6	9	27	27
69	13	13	10	9	45	44
70	20	17	21	23	81	80
71	10	10	12	11	43	42
72	12	7	10	10	39	38
73	7	7	8	10	32	32
74	9	9	9	15	42	41
75	5	9	10	7	31	31

* The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/year.

* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field deployed dosimeters by Landauer.

M= Below minimum reportable quantity.

Conclusions

The data are showing elevated readings at four of the five cylinder yards. These annual doses are in excess of the state/DOE primary dose limit for members of the public where the public has access. The yards may also produce ten or fifteen percent additional mrems in neutron as well as gamma doses. Neutron dosimetry is being gathered in another division program. Monitoring of the B-yard will discontinue based on the evidence that no substantial readings were found in two quarters of data, after the removal of the UF6 cylinders from the yard.

References

Bechtel Jacobs Company, LLC. 1998. *East Tennessee Technology Park UF_6 Cylinder Yards Final Safety Analysis Report.*

Tennessee Department of Environment and Conservation. Department of Energy Oversight Division. 2005. *Environmental Monitoring Plan January through December 2005.*

Thomasson, D.A. 2005. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

U.S. Department of Energy. Office of Nuclear, Science and Technology. 1999. *Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.*

CHAPTER 5 RADIOLOGICAL MONITORING

Real Time Ambient Gamma Monitoring of the Oak Ridge Reservation

Principal Authors: Gary Riner, Howard Crabtree, Natalie Pheasant

Abstract

In 2005, the Tennessee Department of Environment and Conservation placed gamma exposure rate monitors at a background location (Fort Loudoun Dam), the entrance to Y-12's Industrial Landfill, the fence near the exit of Oak Ridge National Laboratory's Molten Salt Reactor, and the weigh-in station at the Environmental Management Waste Management Facility (EMWMF) in Bear Creek Valley near the Y-12 National Security Complex. Measurements collected from these sites ranged from 6 to 475 μrem/hour. The highest measurements reported were at the EMWMF during the delivery of soils/sediments from the remediation of the Homogeneous Reactor Experiment Retention Basin and wastes from the K-770 Scrap Yard at East Tennessee Technology Park. All results were below limits specified by State and Nuclear Regulatory Commission regulations requiring their licensees to conduct operations in such a manner that the external dose in any unrestricted area does not exceed 2.0 millirem (2,000 μrem) in any one-hour period.

Introduction

The Tennessee Department of Environment and Conservation (TDEC), DOE Oversight Division has deployed continuously recording exposure rate monitors on the Oak Ridge Reservation (ORR) since 1996. While the environmental dosimeters used in the division's Ambient Monitoring Program provide the cumulative dose over the time period monitored, the results cannot account for the specific time, duration, and magnitude of fluctuations in the dose rates. Consequently, a series of small releases cannot be distinguished from a single large release, using the dosimeters alone. The continuous exposure rate monitors record gamma radiation levels at short intervals (e.g., 1 minute), providing an exposure rate profile that can be correlated with activities or changing conditions at a site. The instruments have primarily been used to record exposure rates during remedial activities and to supplement the integrated dose rates provided by the division's environmental dosimetry.

In 2005, the exposure rate monitors were placed at four locations: the background station located at Fort Loudoun Dam in Loudon County, the Y-12 Industrial Landfill, the Molten Salt Reactor Experiment (MSRE at ORNL), and the Environmental Management Waste Management Facility (EMWMF) located in Bear Creek Valley near the Y-12 National Security Complex.

Methods and Materials

The exposure rate monitors used in the program are manufactured by Genitron Instruments and marketed under the trade name GammaTRACER.® Each unit contains two Geiger-Mueller tubes, a microprocessor controlled data logger, and lithium batteries sealed in a weather resistant case to protect the internal components. The instruments can be programmed to measure gamma exposure rates from 1 μrem/hour to 1 rem/hour at predetermined intervals (one minute to two hours). The results reported are the average of the measurements recorded by the two Geiger-Mueller detectors, but data from each detector can be accessed if needed. Information recorded by the data loggers is downloaded to a computer using an infrared transceiver and associated software. Monitoring in the program focuses on the measurement of exposure rates under conditions where gamma emissions can be expected to fluctuate substantially over relatively short periods and/or there is a potential for the unplanned release of gamma emitting radionuclides to the environment. Candidate monitoring locations include: remedial activities, waste disposal operations, pre and post operational investigations, and emergency response activities.

Results recorded by the monitors are evaluated by comparing the data to background measurements and state radiological standards.

Results and Discussion

The amount of radiation an individual can be exposed to is restricted by state and federal regulations. The primary dose limit for members of the public specified by these regulations is a total effective dose equivalent* of 100 mrem in a year. Since there are no agreed upon levels where exposures to radiation constitute zero risk, radiological facilities are also required to maintain exposures as low as reasonably achievable (ALARA). Table 1 provides some of the more commonly encountered dose limits.

Table 1: Commonly Encountered Dose Limits for Exposures to Radiation

Dose Limit	Application
5,000 mrem/year	Maximum annual dose for radiation workers
100 mrem/year	Maximum dose to a member of the general public
25 mrem/year	Limit required by state regulations for free release of facilities that have been decommissioned
2 mrem in any one hour period	The state limit for the maximum dose in an unrestricted area in any one hour period

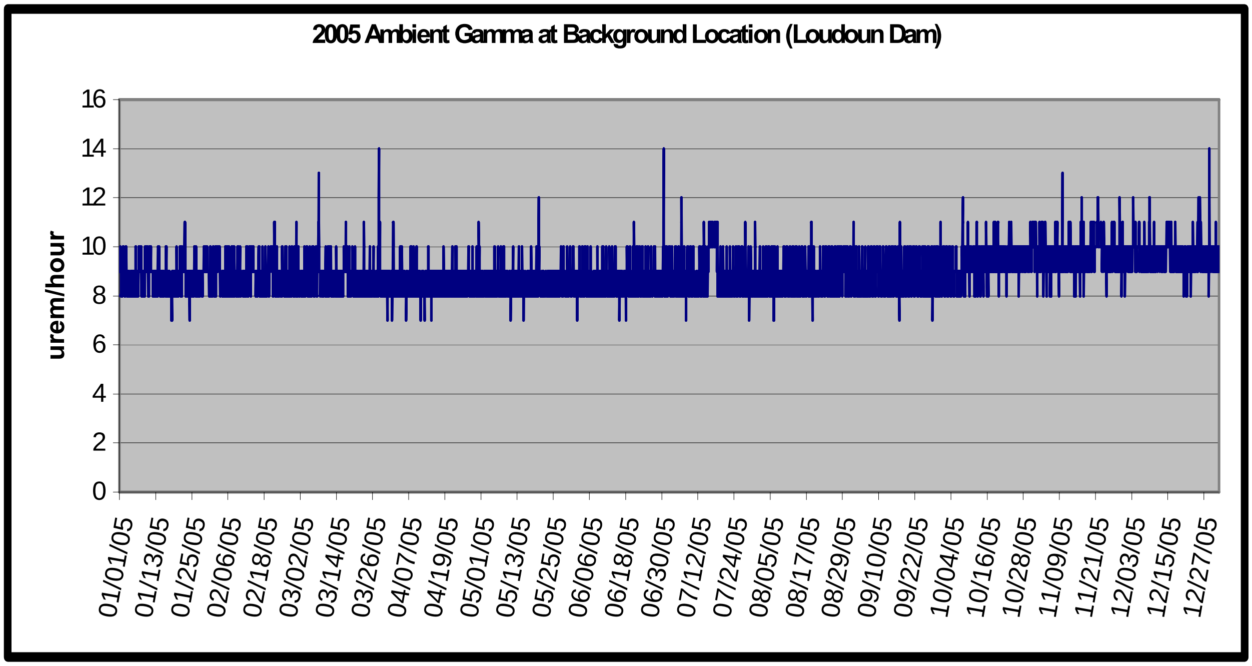
The unit used to express the limits (rem) refers to the dose of radiation an individual receives: that is, the radiation absorbed by the individual. For alpha and neutron radiation, the measured quantity of exposure, roentgen (R), is multiplied by a quality factor to derive the dose. For gamma radiation, the roentgen and the rem are generally considered equivalent. The more familiar unit, rem, is used in this report to avoid confusion. It should be understood, the monitors used in this program only account for the doses attributable to external exposures from gamma radiation. Any dose contribution from alpha, beta, or neutron radiation would be in addition to the measurements reported.

In 2005, gamma monitoring stations for the program included the background location at Fort Loudoun Dam in Loudon County, Y-12's Industrial Landfill, MSRE (ORNL) and the weigh-in station for the EMWMF in Bear Creek Valley near the Y-12 National Security Complex.

<u>Fort Loudoun Dam Background Station</u>: Background exposure rates fluctuate over time due to various phenomena that alter the quantity of radionuclides in the environment and/or the intensity of radiation being emitted by these radionuclides. For example, the gamma exposure rate above soils saturated with water after a rain can be expected to be lower than that over dry soils, because

* Dose equivalent is the product of the absorbed dose in tissue and a quality factor. Total Effective Dose Equivalent means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). The deep dose equivalent refers to the dose equivalent in tissue at 1 cm derived from external (penetrating) radiation. Dose contributions from background radiation and medical applications are not included in the dose calculation.

the moisture shields radiation released by terrestrial radionuclides. To better assess exposure rates measured on the reservation and the influence that natural conditions have on these rates, division personnel maintain one of the division's gamma monitors at Fort Loudoun Dam in Loudon County to collect background information. Figure 1 depicts the exposure rates measured at the background station from 01/01/05 to 12/31/05. Over this period exposure rates averaged 9 μrem/hour and ranged from 7 to 14 μrem/hour.



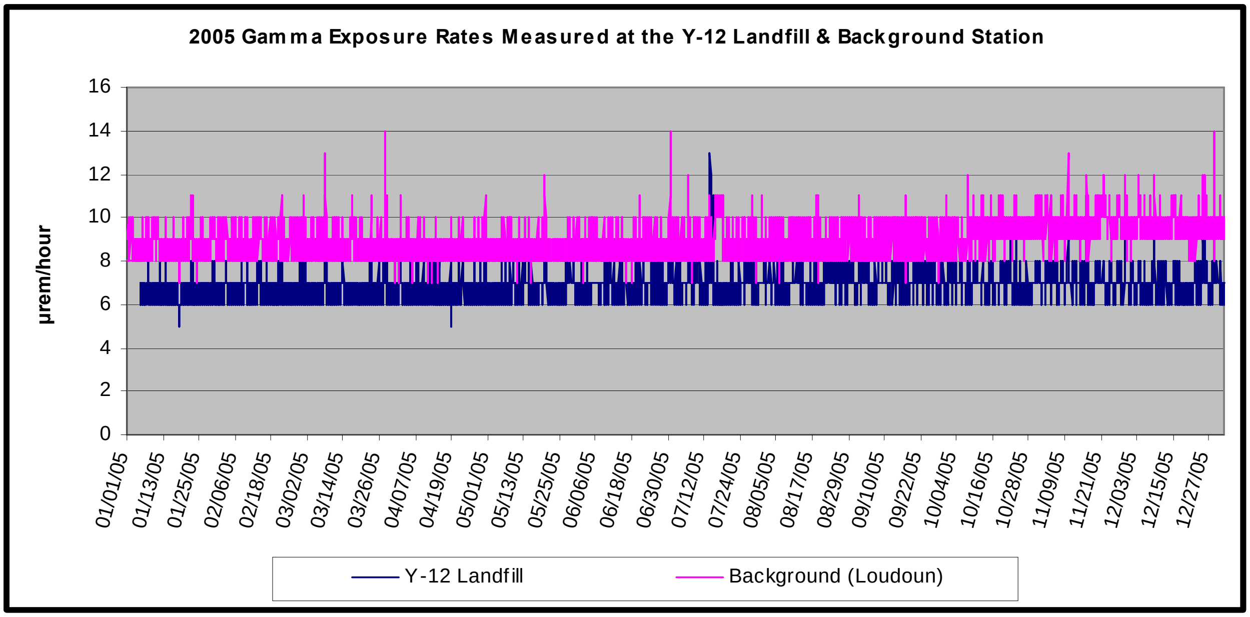
The state dose limit to an unrestricted area is 2 mrem (2,000 μrem for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 1: 2005 Results of Exposure Rate Monitoring at the Background Station Located at Fort Loudoun Dam in Loudon County

On average, individuals in the United States receive a dose of approximately 300 mrem/year from naturally occurring radiation. Most of this dose is from internal exposures received as a result of breathing radon and its daughter radionuclides.

<u>The Y-12 Industrial Landfill</u>: The Y-12 Industrial Landfill is permitted by TDEC's Division of Solid Waste Management with the provision that the facility shall not dispose of radioactive wastes. While wastes are screened prior to disposal at the facility, instances have occurred where radionuclides have been found at the landfill in violation of this agreement.

On December 11, 2002, staff placed one of the gamma monitors at the entrance to the facility to measure gamma activity as wastes were transported through the gate for disposal. The monitor was programmed to increase the frequency of measurements recorded from one-hour to one-minute intervals, if exposure levels exceeded 20 μrem/hour. To date, the results have all been similar to background measurements, except for one occasion when a calibration source being used at the site was detected by the monitor. In 2005, the measurements ranged from 5 to 13 μrem/hour and averaged 7 μrem/hour (Figure 2).



The state dose limit to an unrestricted area is 2 mrem (2,000 µrem for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 2: 2005 Gamma Exposure Rates Measured at the Entrance to the Y-12 Industrial Landfill and Background Station (Fort Loudoun Dam)

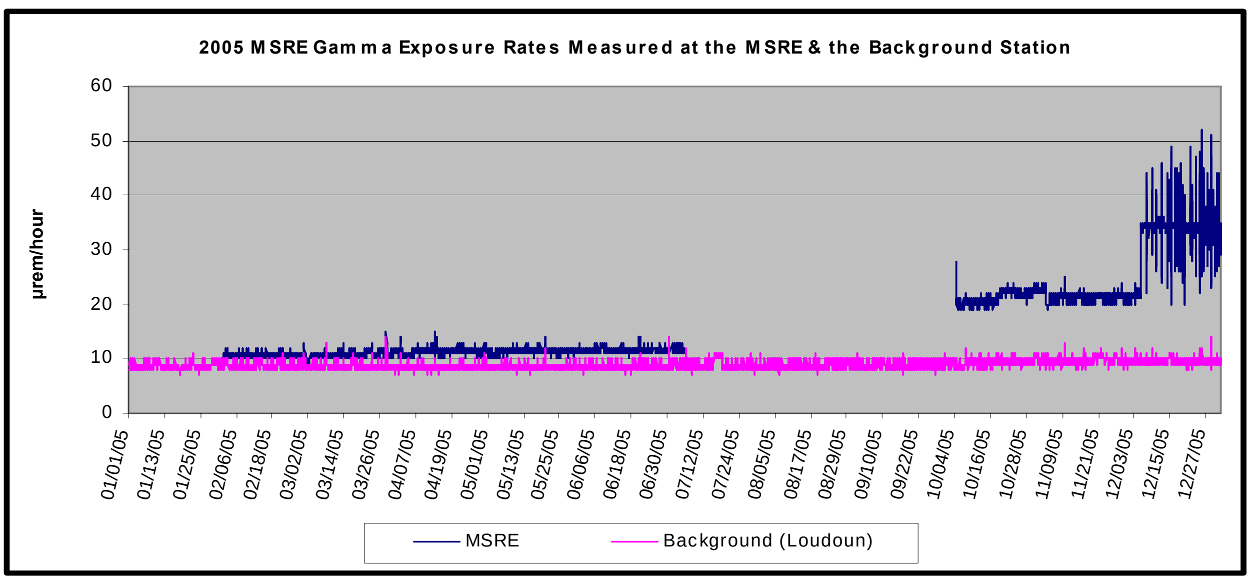
The Molten Salt Reactor Experiment (MSRE): The concept of a molten salt rector was first explored at ORNL in association with a 1950s campaign to design a nuclear powered airplane. After interest in an atomic airplane subsided, the Molten Salt Reactor was constructed to evaluate the feasibility of applying the technology to commercial power applications. The concept called for circulating uranium fluoride (the fuel) dissolved in a molten salt mixture through the reactor vessel. The Molten Salt Reactor achieved criticality in 1965 and was used for research until 1969.

When the reactor was put into shut down mode, the molten fuel salts and flush salts were transferred to drain tanks and allowed to solidify. In 1994, an investigation of the MSRE discovered elevated levels of uranium hexafluoride and fluorine gases throughout the off-gas piping connected to the drain tanks. Among other problems, uranium had migrated through the system to the auxiliary charcoal bed, creating criticality concerns. Actions were taken to stabilize the facility and a CERCLA Record of Decision issued in July 1998 requiring the removal, treatment, and safe disposition of the fuel and flush salts from the drain tanks.

On two occasions during 2005 (Figure 3), staff attached one of the monitors to a fence near where the trucks containing the radioactive materials exit the MSRE in anticipation of the fuel being removed from the drain tanks and transported to a storage area. The remedial action called for salts to be melted in the tanks, fluorinated, then the uranium removed in the form of gaseous uranium hexafluoride. Processing of the flush salt tank was initiated in December 2004 and completed in June 2005, with the recovered uranium transported to an on-site storage facility. However, the salts themselves could not be removed due to a blocked line encountered during the process.

Measurements taken during the period the uranium was removed from the MSRE (February 1 to July 5) averaged 11 μrem/hour and ranged from 8 to 15 μrem/hour, which is only slightly above background measurements. The monitor was removed July 5th, downloaded, and returned to the site on October 4th to monitor the removal of uranium from the fuel drain tanks, which is currently scheduled to be completed in 2006.

During the monitoring interval from October 4 through the end of 2005, the exposure rates increased to an average of 31 μrem/hour and ranged from 19 to 52 μrem/hour. The overall increase in the results is believed to be due to a contaminated salt melting probe that had been placed near the monitoring location in August. When the monitor was positioned on October 4th, the contaminated end of the salt melting probe was pointed away from the monitor and shielded by lead blankets. The measurements nevertheless rose from the near background levels recorded earlier in the year to approximately 28 μrem/hour, then dropped abruptly within a couple hours after placement. On December 1st, the salt melting probe was reoriented so that the contaminated end was next to the fence and the TDEC gamma tracer. However, no change in dose rate was noted. When staff returned to check on the monitor on December 5th, they found that the monitor had been repositioned and secured behind a steel gatepost. The steel post is believed to have shielded radiation emitted by contamination on the probe (at both orientations), resulting in the abrupt decrease in the readings seen within hours of placement of the monitor at the site on October 4th. The highest values were recorded after the monitor was returned to its original position, averaging 35 μrem/hour from December 5 through December 31.



The state dose limit to an unrestricted area is 2 mrem (2,000 μrem for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 3: 2005 Gamma Exposure Rates Measured at the Gate of MSRE and the Background Station at Fort Loudoun Dam

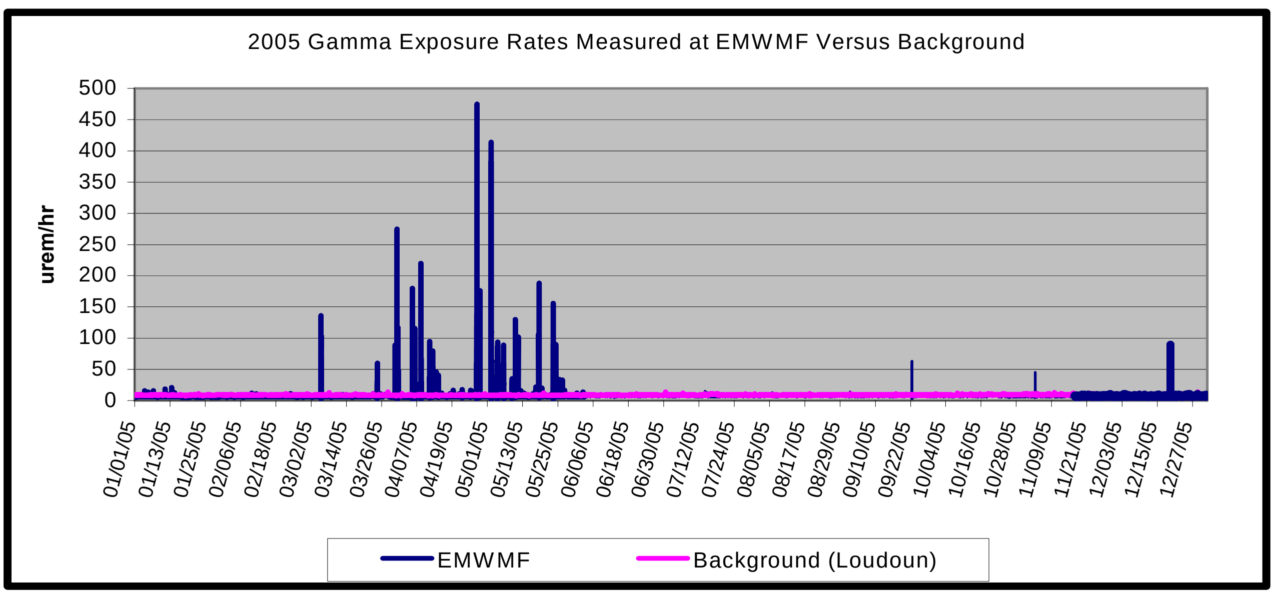
<u>The Environmental Management Waste Management Facility (EMWMF)</u>: The EMWMF was constructed in Bear Creek Valley (near the Y-12 Plant) to dispose of wastes generated by CERCLA activities on the ORR. The EMWMF relies on a waste profile provided by the generator to characterize waste disposed of in the facility. This profile is based on an average of contaminants in a waste lot. Since the size of waste lots can vary from a single package to many

truckloads of waste, the averages reported are not necessarily representative of each load of waste transported to the facility. That is, some loads may have highly contaminated wastes, while other loads may contain very little contamination.

To get an understanding of the variability in radioactive waste disposed of at the EMWMF, one of the gamma monitors was secured at the facility's check-in station on August 27, 2002. Each truck transporting waste for disposal is required to stop at this location while the vehicle/waste is weighed and the driver processes the associated manifest. In 2005, the monitor was programmed to record measurements at fifteen-minute intervals at exposure rates below 40 µrem/hour and at one-minute intervals at exposure levels above 40 µrem/hour.

When waste containing gamma emitters are not near the weigh station, the data reflects exposure levels similar to background measurements. As the trucks carrying gamma emitters pull into the weigh station, the exposure levels increase, peak as the waste moves past the monitor, then abruptly decline as the trucks pull away. While relatively high measurements can be observed in the data, the durations of the elevated readings are only a few minutes. This, coupled with the monitor's inability to read alpha and beta emissions, results in relatively low average values when compared to the maximum exposures measured.

In 2005, the measurements taken at the EMWMF ranged from 6 to 475 µrem/hour (Figure 4) and averaged 8.3 µrem/hour. The highest value, 475 µrem/hour, represents approximately 24% of the state maximum dose to an unrestricted area in any one-hour period (2,000 µrem/hour). This is considerably lower than measurements taken in 2003 and 2004. In 2003, the highest measurements were recorded during the delivery of sediments dredged from the 3513 Waste Holding Basin. The highest of these measurements, 1,612 µrem/hour, represents 81% of the state's limit to unrestricted areas. The highest exposure rates recorded in 2004 were taken during the delivery of wastes associated with the Corehole 8 Remediation at ORNL. The highest value, 1,720 µrem/hour, represents approximately 86% of the state maximum dose to an unrestricted area in any one-hour period.



The state dose limit to an unrestricted area is 2 mrem (2,000 µrem for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

Figure 4: 2005 Results of Gamma Exposure Rate Monitoring at the Weigh-In Station for the Environmental Management Waste Management Facility (EMWMF)

The highest exposure levels recorded at the EMWMF in 2005 were during the delivery of soils/sediments from the remediation of the Homogeneous Reactor Experiment (HRE) Retention Basin and ETTP's K-770 Scrap Yard. The retention basin received effluents from operations of the second of two reactors operated at the site from 1951 through 1961. Effluents released to the basin were flocculated, then released to a tributary southeast of the impoundment. While The K-770 Scrap Yard primarily received contaminated scrap metal from the K-25 facility, wastes from other locations were also disposed of in the facility. Anomalies that have been found include casks containing greater than Class C waste, which were recently discovered at the site.

Conclusion

The use of continuously recording gamma exposure monitors has proven to be a flexible and reliable method for monitoring gamma radiation on the reservation. Based on the data collected in 2005:

- Gamma levels at the Y-12 Industrial Landfill were consistent with background measurements.
- Measurements taken at the MSRE were not indicative of any releases during the removal of uranium collected from the flush salt tanks. Increases in the exposure levels measured during the second part of the year have been attributed to a contaminated salt probe placed near the monitor, with associated fluctuations due to repositioning of the monitor.
- Measurements taken at the EMWMF ranged from 6 to 475 μrem/hour and averaged 8.3 μrem/hour. The highest value, 475 μrem/hour, represents approximately 24% of the state maximum dose to an unrestricted area in any one-hour period (2,000 μrem/hour). The highest measurements recorded were during the delivery of wastes from the remediation of the Homogeneous Reactor Experiment Retention Basin and ETTP's K-770 Scrap Yard.

References

Bechtel 1988, *Remedial Investigation Plan for ORNL Waste Area Grouping 9 Oak Ridge National Laboratory Remedial Investigation/Feasibility Study*. ORNL/RAP-Sub/87-30b-99053C/13. June 1988.

Bechtel. 1992. *Site Characterization Summary Report for Waste Area Grouping 1 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*. DOE/OR-1043/V1&D1. September 1992.

National Research Council, 1997. *Evaluation of the U.S. Department of Energy's Alternatives for the Removal and Disposition of Molten Salt Reactor Experiment Fluoride Salts (1997)*. National Academy Press. Washington D.C. 1997.

ORNL 1996. *White Oak Creek Watershed: Melton Valley Area Remedial Investigation Report, Oak Ridge National Laboratory, Oak Ridge Tennessee*. DOE/OR/01-1546/V1&D1. November 1996.

Stansfield and Francis 1986, *Characterization of the Homogeneous Reactor Experiment No. 2 (HRE) Impoundment Environmental Science Division.* ORNL/TM-10002. July 1986.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement Between the state of Tennessee and the Department of Energy*. Oak Ridge, Tennessee. 2001.

Tennessee Department of Environment and Conservation, 2004. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division Environmental Monitoring Plan January through December 2005.* December 2004. Oak Ridge, Tennessee.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division*. Oak Ridge, Tennessee.

U.S. Department of Energy (DOE). 1998. *Record of Decision for Interim Action to Remove Fuel and Flush Salts from the Molten Salt Reactor Experiment Facility at the Oak Ridge National Laboratory, Oak Ridge, Tennessee.* (DOE/OR/02-1671&D2). June 1998.

U.S. Department of Energy (DOE). 2000. *The Surface Impoundment Operable Unit. Fact Sheet*. September 2000.

U.S. Department of Energy (DOE). 2004. *DOE Oak Ridge Environmental Management Program Progress Update*. April 2004.

U.S. Department of Energy (DOE). 2006. *DOE Oak Ridge Environmental Mangement Program Melton Valley*. Factsheet at http://www.bechteljacobs.com/pdf/factsheets/melton_valley.pdf. January 2006.

U.S. Science Applications International Corporation (SAIC), 2003. *2003 Remedial Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee.* DOE/OR/01-2058&D1. March 2003.

CHAPTER 5 RADIOLOGICAL MONITORING

Biological Sampling and Radiochemical Analysis of Aquatic Plants (Macrophytes) at Spring Habitats on the Oak Ridge Reservation

Principal Author: Chris Yarnell, Robert Storms

Abstract

This project is an expansion of a pilot vegetation (watercress) sampling and radiochemical analysis effort begun by division staff in 1995 as part of environmental surveillance per the Tennessee Oversight Agreement. The project had been idle since that time due to inconclusive results and laboratory budget constraints. The project was revitalized in 2002. Metals were added in 2004 as potential contaminants of interest. After reviewing the laboratory data for the metals from 2004, the metals constituents were dropped from the sampling protocol in 2005. The concentrations of metals in the samples collected and analyzed posed little to no threat to the public and/or the environment. The 2005 study was designed to return to the areas with the highest historical radionuclide activity from the previous sampling events. The division planned to correlate previous watercress/vegetation radiochemistry data with current watercress/vegetation radiochemistry data sampled from the same ORR springs as an aid in determining if aquatic vegetation is bioaccumulating radiological contaminants above the Safe Drinking Water Act (SDWA) Action Levels. The SDWA Action Level of 15 pCi/L was used for gross alpha, beta and photon emitters. This level is listed as 4 mrem/year to the total body or any given internal organ. Beta and photon emitters can use 50 pCi/L for a greater than 100,000 population screen and 15 pCi/L for a vulnerable system screen. Division staff gathered vegetation monitoring data in support of the groundwater monitoring and sampling of springs and surface water impacted by hazardous substances. “Vegetation” sampled included watercress (*Rorippa nasturtium-aquaticum*), other aquatic macrophytes (i.e., *Salvinia sp*., *Sagittaria latifolia,Typha latifolia,* etc), and green algae. Eighteen (18) vegetation samples from reference springs/creeks/ponds (offsite) and onsite springs/creeks/ponds were sampled during 2005. Two sites that were to be sampled in 2005 were visited multiple times but never sampled due to lack of vegetation. Sample collection times were random as there was no need in this case to organize a schedule into wet and dry season sampling events.

Introduction

Aquatic macrophytes (i.e., watercress, water spangles, arrowhead, and cattails), lichens, mosses and green algae are environmental bioindicators and important pathways by which contaminants infiltrate the ORR ecosystem and food chain creating ecological and human health risks. Watercress, a floating, rooted, aquatic plant (macrophyte or angiosperm) was selected for its affinity to thrive around its natural habitat, in clear, lotic water near the mouth of springs and spring-fed creeks. Emerging spring water, if impacted by hazardous substances, will deposit these substances in sediments. In turn, plants will uptake the contaminants both from the water and the sediments. Watercress is naturally high in calcium, alkaline salts, sulfur, and potassium, so it is likely that strontium (a beta emitter) would be uptaken as well, since calcium and strontium belong to the same group (Group IIA) of the periodic chart of the elements. Also, potassium and cesium belong to Group IA creating a similar scenario. Watercress sample analytical results collected during Phase 1 sampling (2002) support this theory as two samples exhibited low cesium-137 concentrations. During the first year of this project, watercress was the main bioindicator sampled supplemented with a few green algae, periphyton and macrophyte samples. Sampling of algae or other aquatic macrophytes was initiated and substituted when watercress was absent or too sparse for sampling at spring sampling habitats.

Green algae and periphyton (benthic algae – diatoms) occur in most all the aqueous and many terrestrial habitats on the ORR (algae is ubiquitous). Algae forms colonies or filamentous mats ("blooms" or slick gelatinous mucilage) often covering a large area of a pond, waterfall ledges, lentic (still) or lotic (moving) water, or lake. Often they are attached to various substrates such as submerged logs and snags, aquatic plants, sand, gravel, and rocks. Periphyton biomass is a primary producer generating much of the low-end of the food chain for many aquatic macroinvertebrates, fish and herbivores. Periphyton are sensitive indicators of environmental physiochemical change in lotic waters. Since they are benthic, the assemblage or population serves as a good bioindicator due to their tolerance or sensitivity to specific changes in environmental condition known for many algal species including diatoms (modified from U.S. DOE, April 2001).

Eighteen habitats both offsite and onsite the ORR consisting of springs, seeps, wetlands, ponds, and spring-fed creeks, with historically elevated radiochemical levels received priority for sampling. Table I provides field data collected at the time of sampling and Table 2 provides the laboratory radiochemical data for each sampling station, including the historical elevated concentration for which the sample was chosen. Map 1 depicts the locations of the samples collected on the ORR. One sample was located off-site as a reference point in Norris, Tennessee (not shown on the map).

Methods and Materials

Procedures employed during the project are consistent with those contained in the TDEC DOE-O Work Plan for the Walkover Survey Program for field radiological surveys and aquatic sampling. Radiological instruments were used to scan bagged samples for beta and gamma radiation prior to delivery to the state Environmental Laboratory in Knoxville. Subsequently, the Knoxville laboratory forwards all radiological samples to Nashville (state of Tennessee Environmental Laboratories) for radiochemical analysis.

Arrangements were made with the appropriate TOA coordinators to expedite sampling in radiological control areas by having radcon technicians available for sample and equipment screening. All samples collected in the field were double bagged in plastic zip-lock baggies, marked and tagged, and packed in coolers with ice for transport to the lab. Field notes and chain-of-custody forms were recorded and documented at each field sampling station. Field sample names were assigned using previous identification numbers (i.e., "BIO 1", "BIO-2", etc.). If the previously assigned identification number was not in the same format as shown above, it was renamed with a new unused number. QA/QC measures and field sampling equipment decontamination procedures were practiced to prevent cross-contamination and mix-up of field samples. Field coordinates (latitude/longitude) were recorded at each sampling station using a Garmin GPS II Plus field unit. Field sampling protocols and methods followed currently accepted and suggested guidelines of the Federal Radiological Monitoring and Assessment Center (FRMAC, 1998), the USGS (Porter, et al., 1993), the ASTM (Patrick, 1973), the TDEC DOE-O "Health, Safety, and Security Plan" (Thomasson, 2005), and the EPA (Barbour, et al., 1999).

Target radionuclides being mobile and occurring in the ORR environment as contamination include but are not limited to:
(1) cesium-137
(2) strontium-90

(3) cobalt-60
(4) technetium-90
(5) uranium isotopes and daughter products

Samples were analyzed for gross alpha, gross beta, and gamma radionuclide parameters. Samples are ashed in a muffle furnace and analyses are performed on the ashed sample material. The gamma analysis follows the standard EPA (gamma) 901.1 method. The gross alpha and gross beta analysis is determined by counting 2 grams of ashed sample for two separate counts of 100 minutes.

Results and Discussion

The objectives of this oversight activity and study is the detection and characterization of radionuclides which are being bioaccumulated by both aquatic macrophytes and algal species in ORR spring habitats and aquatic ecosystems affecting the low-end food chain. The 2005 objective narrowed the scope of sampling to include only locations with elevated historical radionuclides concentrations. The division gathered eighteen (18) vegetation samples during 2005. A purpose of the study was to show that contaminated groundwater emerging from springs was impacting aquatic plant species in the same sampling reach of the spring-fed creeks and streams.

The data collected from this most recent round of sampling events (Appendix A) does indicate limited areas of elevated radionuclide concentrations in the watercress/vegetation both on and off of the ORR. The elevated radionuclide concentrations in the vegetation are below their respective SDWA Action Levels. Future endeavors will focus on pinpointing areas of concern within the ORR to more closely evaluate the potential for hot spots. Fieldwork will consist of walkover surveys, spring seep surveys, and watercress/vegetation sampling.

Conclusions

Adequate evidence of vegetation bioaccumulation of radionuclides has been determined to warrant further investigations. The historically elevated levels did not indicate that these eighteen locations sampled could be considered “hot spots” due to the fact that the results for all locations were below the SDWA Action Levels. The 2006 plan will be to further investigate the ORR and evaluate the potential for new (not previously sampled) “hot spot” locations. The division will continue to sample and monitor aquatic vegetation both offsite and on the ORR to monitor aquatic ecosystem health and stream recovery.

References

Barbour, M.T., et al. 1999. *Rapid Bioassessment for use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish.* Second Edition. EPA 841-B-99-002. Environmental Protection Agency. Washington, D.C.

Barnthouse, Lawrence W. December 1995. *Effects of Ionizing Radiation on Terrestrial Plants and Animals: A Workshop Report*. Environmental Sciences Division Pub. Nu. 4494. ORNL/TM-13141. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Britton, L. J., and P.E. Greeson. 1989. *Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples*. Book 5, Chapter A4, Techniques of Water of Water Resources Investigations of the U. S. Geological Survey. U.S. Department of the Interior. U.S. Government Printing Office, Washington, D.C. http://www.deq.state.mt.us/ppa/mdm/SOP/pdf/12-1-2-0.pdf

FRMAC. 1998. *FRMAC Monitoring and Sampling Manual, Vols. 1 & 2*. DOE/NV/11718-181-Vol. 1 & Vol. 2. Federal Radiological Monitoring and Assessment Center, Nevada Test Site. http://www.nv.doe.gov/programs/frmac/DOCUMENTS.htm

Garten, Jr., C.T., and R.D. Lomax. June 1987. *Strontium-90 Contamination in Vegetation from Radioactive Waste Seepage Areas at ORNL, and Theoretical Calculations of Sr-90 Accumulation by Deer*. Environmental Sciences Division Pub. No. 2924, ORNL/TM-10453, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Patrick, R. 1973. *Use of Algae, Especially Diatoms, in the Assessment of Water Quality*. From Biological Methods for the Assessment of Water Quality (Edited by Cairns, J. and K.I. Dichson), pp. 76-95. American Society of Testing and Materials (ASTM), Philadelphia, Pennsylvania. http://www.astm.org

Porter, Stephen D., et al. 1993. *Methods for Collecting Algal Samples as Part of the National Water-Quality Assessment Program (NAWQA).* U.S. Department of the Interior. U.S. Geological Survey Open File Report 93-409. Raleigh, North Carolina.

Quinn, Tom. 2001. Integrating Aquatic Ecosystem Data. U.S. Department of the Interior, U.S. Geological Survey. Wyoming Department of Environmental Quality. Cheyenne, Wyoming. http://wy.water.usgs.gov/projects/emap/

U.S. Army Corps of Engineers. November 1995. *Wetlands Delineation Manual*. http://www.wetlands.com/regs/tlpge02e.htm

U.S. Department of Energy. April 2001. *Biological Monitoring and Abatement Program (BMAP).* Oak Ridge National Laboratory, Environmental Sciences Division. http://www.esd.ornl.gov/BMAP

U.S. Environmental Protection Agency. December 2000. Safe Drinking Water Act, Federal Register, Volume 65, Number 236, Rules and Regulations. http://www.epa.gov/safewater/rads/radfr.pdf

U.S. Environmental Protection Agency. August 2002. Biological Indicators of Watershed Health – *Periphyton as Indicators*. http://www.epa.gov/region09/lab/sop/1131.pdf

Thomasson, D.A. 2005. *Health, Safety and Security Plan*. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

Appendix A: Locations and Vegetation Sampled for Radiochemical Analysis

Table A1: Locations and Aquatic Vegetation Sampled for Radiochemical Analysis

SAMPLE FIELD DATA					
Sample ID	**Sample Location**	**Sample Material**	**Latitude (degrees)**	**Longitude (degrees)**	**Date Sampled**
BIO-3	West Bear Creek Valley Seep	sparganium/other water weeds	35.94553	-84.32222	07/20/2005
BIO-5	21002 Spring ETTP	green algae	35.93869	-84.41298	05/27/2005
BIO-6	USGS 10895 ETTP	watercress/green algae	35.95279	-84.38940	05/27/2005
BIO-21	Clear Creek Reference Site Norris (off-site)	watercress	36.21611	-84.05194	05/06/2005
BIO-22	Sycamore Spring ORNL	sparganium	35.91431	-84.33760	07/19/2005
BIO-31	K-Yard Pool Water ETTP	cattails	35.93701	-84.41118	07/21/2005
BIO-35	Bootlegger Spring UT Arboretum	watercress	35.99611	-84.22279	05/06/2005
BIO-38	Periwinkle Spring UT Arboretum	watercress/other water weeds	35.99518	-84.20220	08/11/2005
BIO-48	Cattail Spring East	scouring rush	35.99784	-84.22550	05/06/2005
BIO-61	Cabin Spring Y-12 Landfill	watercress	35.96897	-84.27000	05/10/2005
BIO-62	Cephus Spring Y-12 Landfill	watercress	35.96707	-84.26180	05/10/2005
BIO-63	North Cephus Spring Y-12 Landfill	watercress	35.96696	-84.26210	05/10/2005
BIO-64	Parcel 10 Spring Highway 95	watercress	35.89575	-84.32490	05/11/2005
BIO-65	SS-4 Spring Bear Creek Valley	watercress/red and green algae	35.96238	-84.29290	05/25/2005
BIO-66	SS-5 Spring Bear Creek Valley	red and green algae	35.95656	-84.30100	05/25/2005
BIO-67	K-1007 Pond (west) ETTP	green algae	35.92656	-84.39460	08/24/2005
BIO-68	1st Creek (low) ORNL	watercress	35.92156	-84.31870	10/25/2005
BIO-70	1st Creek (high) ORNL	watercress	35.92474	-84.32110	10/25/2005

Table A2: Results for Radiochemical Analysis of Aquatic Vegetation

Sample ID	Historic Beta Activity**	Gross Alpha Activity/error	Gross Beta Activity/error	Gamma Radionuclide Activity/error						
				Pb-212	Pb-214	Bi-214	Ac-228	Be-7	K-40	Tl-208
BIO-3	12.87	0.046/0.019	5.06/0.12	ND	ND	0.042/0.010	ND	ND	2.59/0.16	ND
BIO-5	6.47	0.56/0.19	8.44/0.46	0.1109/0.0069	0.148/0.010	0.145/0.012	0.156/0.019	ND	1.73/0.10	ND
BIO-5D*	NA	0.57/0.18	7.90/0.45	NS	NS	NS	NS	NS	NS	NS
BIO-6	6.13	0.44/0.15	5.99/0.37	0.159/0.028	0.458/0.052	0.920/0.070	ND	ND	ND	0.090/0.022
BIO-21	5.56	0.012/0.014	4.80/0.10	ND	0.0228/0.0066	0.0497/0.0079	ND	ND	2.40/0.12	ND
BIO-22	9.39	0.107/0.065	11.27/0.35	0.0798/0.0083	0.072/0.011	0.075/0.012	0.150/0.021	ND	4.17/0.20	0.0255/0.0064
BIO-22D	NA	0.118/0.074	10.34/0.33	NS	NS	NS	NS	NS	NS	NS
BIO-31	7.56	0.003/0.019	4.06/0.12	ND	ND	0.040/0.011	ND	ND	2.47/0.17	ND
BIO-35	5.14	0.030/0.016	4.06/0.10	0.0197/0.0047	ND	ND	ND	0.294/0.046	2.37/0.13	0.0175/0.0050
BIO-38	5.60	0.018/0.013	3.562/0.072	ND	0.111/0.024	0.094/0.026	ND	ND	2.63/0.25	ND
BIO-48	9.46	0.018/0.034	6.02/0.21	ND	ND	0.0429/0.0085	ND	0.413/0.055	2.58/0.14	ND
BIO-48D*	NA	0.038/0.043	5.95/0.20	NS	NS	NS	NS	NS	NS	NS
BIO-61	4.81	0.258/0.052	3.09/0.13	0.0638/0.0072	0.132/0.013	0.158/0.014	0.142/0.017	ND	1.13/0.10	ND
BIO-62	5.71	0.354/0.057	2.98/0.12	0.0510/0.0073	0.109/0.012	0.104/0.014	0.117/0.020	ND	0.82/0.10	0.0375/0.0071
BIO-63	NA	0.135/0.035	4.04/0.12	0.0318/0.0064	0.079/0.011	0.058/0.012	0.099/0.021	ND	1.77/0.12	0.0258/0.0044
BIO-64	6.23	0.097/0.030	2.79/0.10	0.0370/0.0065	ND	0.049/0.011	ND	ND	1.35/0.12	ND
BIO-65	NA	0.65/0.12	7.94/0.29	0.1017/0.0099	0.418/0.022	0.454/0.026	0.162/0.024	ND	ND	ND
BIO-66	8.28	0.86/0.15	8.31/0.34	0.0818/0.0064	0.1200/0.0099	0.149/0.012	0.091/0.014	0.426/0.062	1.177/0.089	0.0213/0.0043
BIO-67	5.93	0.238/0.090	6.67/0.23	0.092/0.016	ND	0.181/0.038	0.274/0.037	1.68/0.21	ND	ND
BIO-67D	NA	0.282/0.088	6.40/0.23	NS	NS	NS	NS	NS	NS	NS
BIO-68	10.90	0.044/0.012	4.698/0.081	0.0321/0.0087	ND	0.079/0.015	ND	ND	1.79/0.16	ND
BIO-70	NA	0.013/0.010	4.535/0.080	0.0291/0.0080	ND	ND	ND	ND	1.76/0.15	ND

*BIO-#d = Duplicate sample run for QA/QC (only Gross Alpha & Beta Activity were run on Duplicate samples)
**Data collected from previous TDEC sampling events
NA = Not Applicable
ND = Not Detected in sample
NS = Not Sampled
Activity is given in units of pCi/g wet weight
Error represents + or – value

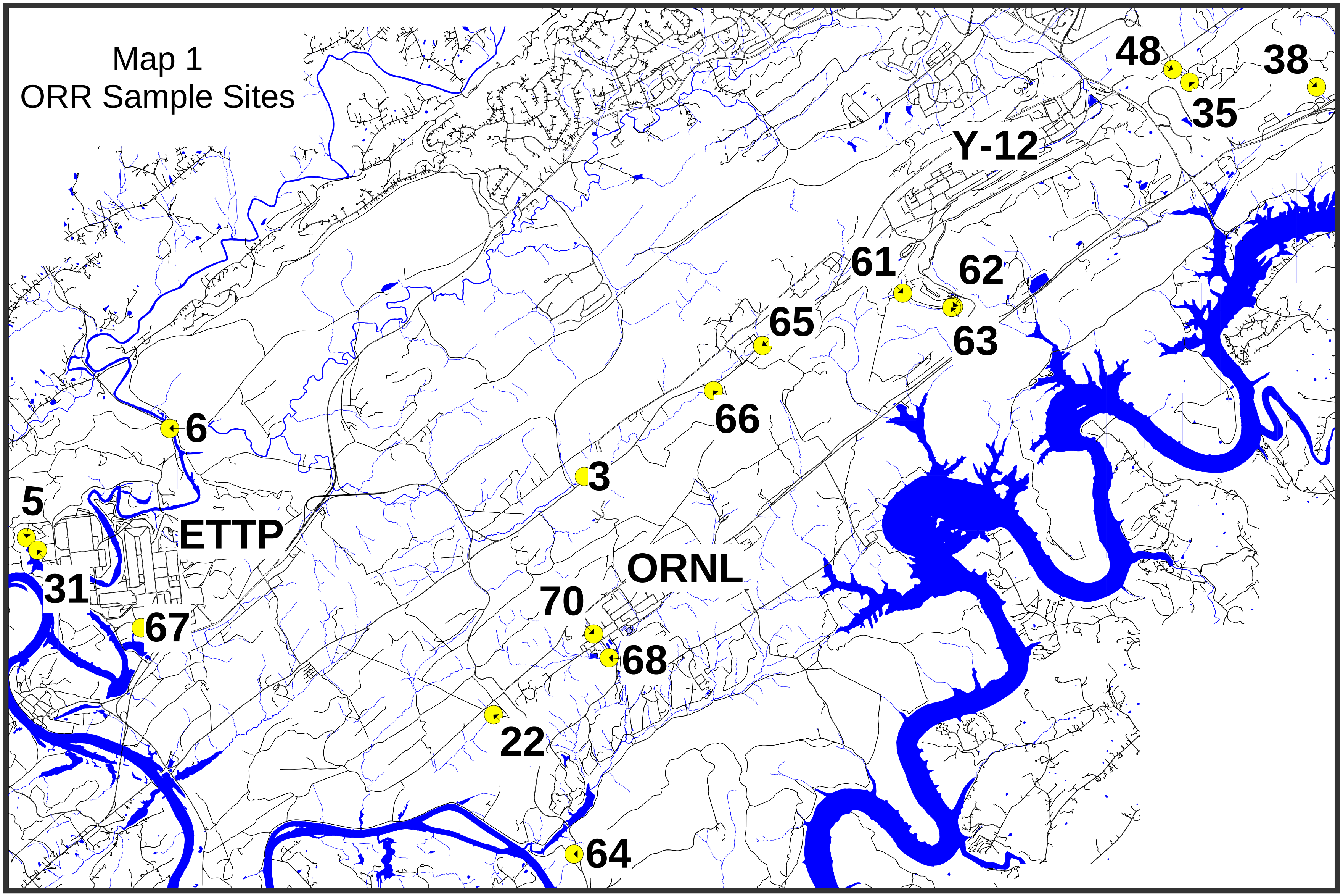


Figure A1: Aquatic Vegetation Sampling Locations

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CHAPTER 5 RADIOLOGICAL MONITORING

Facility Survey and Infrastructure Reduction Program

Principal Author: David Thomasson

Abstract

Like other Department of Energy (DOE) research facilities across the nation, the Oak Ridge Reservation released large quantities of chemical and radiological contamination into the surrounding environment during nearly five decades of nuclear weapons research and development. In response to this history, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the division) developed a Facility Survey Program to document the histories of facilities on the Reservation. The survey program assesses facilities' physical condition, inventories of hazardous chemical and radioactive materials, process history, levels of contamination, and present-day potential for release of contaminants to the environment under varying conditions ranging from catastrophic (i.e. earthquake) to normal everyday working situations. This broad-based assessment supports the objectives of Section 1.2.3 of the *Tennessee Oversight Agreement,* which was designed to inform local citizens and governments of the historic and present-day character of all operations on the Reservation. This information is also valuable for local emergency planning purposes. Since 1994 the division's survey team has characterized 176 facilities and found that thirty-six percent pose a relatively high potential for release of contaminants to the environment. In many cases, this high-potential-for-release is related to legacy contamination that escaped facilities through degraded infrastructures over decades of continual industrial use (e.g. leaking underground waste lines, substandard sumps and tanks, or unfiltered ventilation ductwork). Since the inception of the program, DOE corrective actions (including demolitions) have removed nineteen facilities from the division's list of "high" Potential Environmental Release (PER) facilities. In 2005, eight facilities from this list (K1004-B, K1004-A, K1015, K1004-E, Y9616-3, Y9995, Y9736, Y9720-8) were removed through demolition.

Beginning in 2002 the Facility Survey Program staff began refocusing its primary effort on the oversight of facilities slated for demolition at ORNL and Y-12. This activity was in response to formal, accelerated infrastructure reduction (demolition) programs at each of those sites. Staff completed organized document reviews and field oversight of all activities related to facility demolition. During 2005 staff made 380 field visits before, during, and after the demolition of 27 facilities.

Introduction

The Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the division), in cooperation with the Department of Energy (DOE) and DOE contractors, conducts a Facility Survey Program (FSP) on the Oak Ridge Reservation (ORR). The program provides a comprehensive independent assessment of active and inactive facilities on the reservation based on their: (1) physical condition (2) inventories of radiological materials and hazardous chemicals (3) levels of contamination; and (4) operational history. The ultimate goal of the program is to fulfill the commitments agreed to by the state of Tennessee and the Department of Energy in Section 1.2.3 of the Tennessee Oversight Agreement, which states that *"Tennessee* *will pursue the initiatives in attachments A, C, E, F, and G. The general intent of these action items is to continue Tennessee's: (1) environmental monitoring, oversight and environmental restoration programs; (2) emergency preparedness programs; and (3) delivery of a better understanding to the local governments and the public of past and present operations at the ORR and potential impacts on the human health and/or environment by the ORR."* **The overall objective of the Facility Survey Program is to provide a detailed assessment of all potential hazards affecting or in any way associated with facilities on the Oak Ridge Reservation.** To this end, the program evaluates facilities' potential for release of contaminants to the environment under varying environmental conditions ranging from catastrophic (i.e. tornado, earthquake) to normal everyday working situations. This information is also essential for effective local emergency preparedness planning.

Methods, Materials and Evaluating the Potential for Environmental Release (PER)

Survey program staff takes a historical research approach to evaluating each facility. Prior to commencing fieldwork they examine engineering documents, past contaminant release information, hazard-screening documents, drain databases, and radiological and chemical inventory data. They then perform a walk-through of the facility with the facility manager to gather additional information and to validate information acquired from previously reviewed documents. During the field visit, calibrated radiation survey instruments are used to estimate radiation contamination and dose levels in and around the facility. At the end of the document review and walk-through process, a final report is produced and information is entered into the division's Potential for Environmental Release (PER) database. This database helps the team characterize conditions at each facility based on its physical condition and potential for release of contaminants to the environment.

The PER database is composed of 10 "categories" that relate directly to the contents and condition of the operational infrastructure within and around each facility (Table 1). Each category is assigned a score from 0 to 5 (5 reflects the greatest potential) for each of the 10 "categories" (Table 2). As facilities are scored, totaled, and compared with each other, a relative ranking emerges. Special circumstances, such as legacy releases and professional judgment also influence category scoring. Scores are **not intended to reflect human health risk.** Rather, their sole purpose is to characterize facilities based on the conditions in and around them. This information is used within the division for information, comparison, and review purposes only.

The final facility survey report notifies DOE of the division's findings so that DOE has the opportunity to respond and formulate corrective actions. When the division receives written confirmation from DOE of corrective actions taken on a specific facility, the ranking for that facility is modified accordingly in the PER database. The 10 "categories" that are scored and the "scoring criteria" are presented below in Tables 1 and 2. Table 3 provides a program summary.

Table 1: Categories to be Scored

1.	Sanitary lines, drains, septic systems
2.	Process tanks, lines, and pumps
3.	Liquid Low-level Waste tanks, lines, sumps, and pumps
4.	Floor drains and sumps
5.	Transferable radiological contamination
6.	Transferable hazardous materials contamination
7.	Ventilation ducts and exit pathways to create outdoor air pollution
8.	Ventilation ducts and indoor air/building contamination threat
9.	Radiation exposure rates inside the facility escalated
10.	Radiation exposure rates outside the facility escalated

Table 2: Potential Environmental Release Scoring Guidelines

Score	Score is based on observations in the field and the historic and present-day threat of contaminant release to the environment/building and/or ecological receptors.
0	**No potential**: no quantities of radiological or hazardous substances present.
1	**Low potential**: minimal quantities present, possibility of an insignificant release, very small probability of significant release, modern maintained containment.
2	**Medium potential**: quantities of radiological or hazardous subs. present, structures stable in the near to long term, structures have integrity but are not state-of-the-art, adequate maintenance.
3	**Medium potential**: structures unstable, in disrepair, containment failure clearly dependent on time, integrity bad, maintenance lacking, containment exists for the short term only.
4	**High potential**: quantities of radiological or hazardous subs. present. Containment for any period of time is questionable; migration to environment has not started.
5	**Release**: radiological or hazardous substance containment definitely breached, environmental/interior pollution from structures detected, radiological and/or hazardous substances in inappropriate places like sumps/drains/floors, release in progress, or radiological exposure rates above Nuclear Regulatory Commission (NRC) guidance.
Note: A score of 0 or 1 designates a low Potential Environmental Release rank; a score of 2 or 3 designates a moderate rank; a score of 4 or 5 designates a high rank.	

Discussion and Results

The Facility Survey Program entered its twelfth year in January 2005. As in previous years, inter-agency staff cooperation was excellent; this facilitated the flow of information related to corrective actions, changes in facility status or mission, decommissioning and decontamination activities, and onsite professional activities.

In accordance with past division policy, an individual survey conducted on a facility at K-25 that has been leased to private industry might only address those portions of the facility that are leased. Consequently, some older reports may not include adjacent areas in the same facility or related facilities. These adjacent areas and related facilities may be contaminated and/or exhibit infrastructure problems that are not reflected in the report. Therefore, when reviewing these reports, it is important to look for the phrase “leased area of the facility.” This phrase indicates that the survey report covers only the leased area of the facility, specifically, and is not intended to assess the entire facility or related facility problems (such as drain lines) that may exist outside of the leased area.

Since program staff is continually in the process of evaluating DOE corrective actions taken to address facility concerns, any current ranking may not reflect the most recent corrective actions. Since the inception of the FSP, corrective actions (including demolition) have removed twenty facilities (X3525, X7823-A, X7827, X7819, X3505, Y9404-3, Y9208, Y9620-2, Y9616-3, Y9959, Y9736, Y9720-8, K1025-A, K1025-B, K1015, K1004-E, K1004-A, K1004-B, K1098-F, K1200-C) from the division's list of "high" Potential Environmental Release facilities.

Table 3: Facility Survey Program Summary

	Totals	High PER Facilities	Removed High PER	Facilities Resurveyed	Demolition Visits
A.: Facilities surveyed 1994	15	9	0	0	0
B.: Facilities surveyed 1995	35	11	0	0	0
C.: Facilities surveyed 1996	34	9	0	0	0
D.: Facilities surveyed 1997	23	8	0	0	0
E.: Facilities surveyed 1998	8	3	1	2	0
F.: Facilities surveyed 1999	14	3	0	0	0
G.: Facilities surveyed 2000	14	5	3	0	0
H.: Facilities surveyed 2001	17	8	1	1	0
I.: Facilities surveyed 2002	8	5	5	0	90
J.: Facilities surveyed 2003	4	4	0	0	236
K.: Facilities surveyed 2004	0	0	2	1	463
L.: Facilities surveyed 2005	4	2	**7**	0	380
K.: Totals	**176**	**64**	**19**	**4**	**1169**

Description of the 49 Highest Scoring Facilities (1994-05)

The PER database attempts to reflect the overall condition of a facility and the potential for environmental release. However, it is not the total score of the 10 categories that is always the best indicator of potential for environmental release. Rather, what appears to be the most accurate indicator is the number of categories for which a facility scores a four or five (Table 1). Of the 176 facilities scored since 1994, 64 stood-out with one or more categories scoring a four or five (Table 4). Nineteen of these facilities have been removed through corrective actions or demolition. The following 47 high-scoring facilities are arranged in descending order of total numbers of fours and fives in the PER database.

Table 4: Potential for Environmental Release for 47 High Scoring Facilities

	1	2	3	4	5	6	7	8	9	10		
	DRAIN	TANKS	TANKS	SUMPS	TRANSF	TRANSF	VENT TO	VENT	INT. EXP.	O. EXP.	NUMBER	SURVEY
	LINES	LINES	LINES	DRAINS	RAD.	HAZ.	OUTSIDE	INSIDE	RAD.	RAD.	OF	YEAR
BUILDING	SANI.	PROC.	LLLW	FLOOR	CONT.	CONT.	AIR	SYSTEM	SURVEY	SURVEY	4 and 5's	
X3026	2	3	5	4	5	5	5	5	5	5	8	2005
X3028	0	4	4	3	4	4	4	5	5	3	7	1997
X3517	3	5	5	2	5	3	4	2	5	5	6	2005
Y9731	4	5	1	4	3	5	5	5	3	2	6	2003
K1037-C	0	0	0	0	5	5	5	5	5	4	6	1998
9401-2	1	4	1	4	1	5	4	4	1	0	5	2001
Y9204-3	3	5	2	3	4	5	4	4	2	1	5	2000
X3019-B	2	2	5	3	2	3	4	4	4	4	5	1995
K633	3	5	1	4	5	5	2	5	4	5	5	2002
X7700	4	0	0	3	5	4	2	2	3	5	4	1996
X7700C	4	4	0	4	2	1	2	0	0	4	4	1996
Y9201-4	2	5	0	2	2	4	5	5	2	1	4	1998
K1004-J	5	5	0	4	3	0	0	0	1	1	3	2000
Y9203	4	2	0	4	2	4	2	2	2	0.5	3	1995
X2545	0	3	5	0	4	2	3	0	0	4	3	1995
K1200-C	1	3	0	1	3	5	2	4	3	4	3	1995
Y9769	1	1	0	4	4	2	1	2	4	2	3	1995
X3020	0	0	5	5	5	0	2	0	0	1	3	1997
X3108	0	0	5	5	5	0	2	2	2	2	3	1997
X3091	0	0	5	5	5	1	2	2	3	2	3	1997
Y9738	2	0	0	4	2	4	1	1	2	1	2	2002
Y9743-2	0	3	0	5	3	5	2	2	2	1	2	2001
X3592	0	3	3	2	4	4	3	3	3	2	2	2001
X3504	1	3	0	4	5	0	2	1	2	2	2	2001
X2531	1	1	2	1	5	2	2	1	2	4	2	2001
Y9213	3	1	5	3	3	5	1	1	1	1	2	2000
X7720	0	0	0	0	4	0	0	0	0	4	2	1996
X3001	3	1	2	3	3	2	4	4	3	3	2	1995
K1200-S	2	3	0	3	3	2	3	4	2.5	4	2	1995
X7701	4	3	0	4	2	0	2	0	0	3	2	1996
X7706	4	3	0	4	2	0	2	2	2	2	2	1996
X7707	4	0	0	4	2	3	2	2	0	0	2	1996
Y9736	0	0	0	0	0	4	2	3	0	0	1	2003
Y9959-2	0	0	0	0	1	4	0	0	1	0	1	2003
Y9959	0	0	0	0	1	4	0	0	1	0	1	2003

Table 4: Potential for Environmental Release for 47 High Scoring Facilities cont'd

	1	2	3	4	5	6	7	8	9	10		
	DRAIN	TANKS	TANKS	SUMPS	TRANSF	TRANSF	VENT TO	VENT	INT. EXP.	O. EXP.	NUMBER	SURVEY
	LINES	LINES	LINES	DRAINS	RAD.	HAZ.	OUTSIDE	INSIDE	RAD.	RAD.	OF	YEAR
BUILDING	SANI.	PROC.	LLLW	FLOOR	CONT.	CONT.	AIR	SYSTEM	SURVEY	SURVEY	4 and 5's	
X3085	1	4	3	3	3	2	1	2	3	3	1	1994
X7602	0	2	0	2	4	2	1	3	2	1	1	1997
K1220-N	0	2	0	0	3	2	2	4	2	3	1	1995
X3002	0	2	0	2	3	1	2	3	4	1	1	1996
Y9210	1	0	0	4	1	1	1	2	1	0	1	1995
Y9224	1	0	0	4	1	1	1	2	1	0	1	1995
Y9211	1	0	0	4	1	1	1	2	1	0	1	1995
Y9207	2	0	0	1	1	4	3	1	1	0	1	1995
X7055	0	0	0	4	0	1	1	1	0	0	1	1997
X7700-B	0	0	0	0	3	0	2	0	0	4	1	1996
K1401-L3	1	0	0	1	4	2	1	2	3	1	1	1997
Y9201-3	2	1	0	2	3	5	2	2	2	1	1	1999
*X7819	0	0	0	0	0	0	0	0	0	0	0	1994
*X3505	0	0	0	0	0	0	0	0	0	0	0	2000
*Y9620-2	0	0	0	0	0	0	0	0	0	0	0	1994
*Y9208	0	0	0	0	0	0	0	0	0	0	0	1995
*Y9404-3	0	0	0	0	0	0	0	0	0	0	0	1994
*K1025-A	0	0	0	0	0	0	0	0	0	0	0	1995
*K1025-B	0	0	0	0	0	0	0	0	0	0	0	1996
*Y9616-3	0	0	0	0	0	0	0	0	0	0	0	2002
*Y9959	0	0	0	0	0	0	0	0	0	0	0	2003
*Y9736	0	0	0	0	0	0	0	0	0	0	0	2003
*9720-8	0	0	0	0	0	0	0	0	0	0	0	2005
*K1004-B	0	0	0	0	0	0	0	0	0	0	0	2001
*K1004-A	0	0	0	0	0	0	0	0	0	0	0	2001
*K1015	0	0	0	0	0	0	0	0	0	0	0	2002
*K1004-E	0	0	0	0	0	0	0	0	0	0	0	2002

* Denotes demolished facility

At **Y-12** sixteen facilities had at least one category score of 4 or 5: 9731, 9204-3, 9201-4, 9401-2, 9213, 9743-2, 9203, 9769, 9201-3, 9616-3, 9738, 9210, 9224, 9211, 9207, 9959, 9736, and 9959-2.

Facility Y9731 is the oldest facility in the Y-12 complex. It originally housed the pilot project for the prototype calutron, and the original production facilities for stabilized metallic isotopes, which were used in nuclear medicine. It received four category scores of 5, two category scores of 4, and a total of 37. Most of the facility (outside the office area) today is not receiving preventative maintenance. Process tanks and lines have leaked radiological and hazardous materials throughout the building. Asbestos-containing pipe insulation is peeling and flaking, as is lead-bearing interior and exterior paint. The exhaust fans for the building are not HEPA filtered, and therefore pose a direct pathway to the environment.

Facility Y9204-3 (Beta 3) is one of the original isotope enrichment facilities at Y-12. It received two category scores of 5, three category scores of 4, and a total score of 33. This 250,000sq. ft. facility is now inactive and locked. The largest concerns are leaking PCB-contaminated mineral oil (Z-oil), and radiological contamination. The building has not been sampled above eight feet for radiological contamination, even though the probability of finding it is great. The building historically and presently vents directly to the environment without HEPA filtration.

Facility Y9201-4 (Alpha 4) is also one of the original Y-12 uranium enrichment buildings. It received three category scores of 5, one category score of 4, and a total of 28. The containment integrity of the original process system is weak. This has resulted in breaches that have deposited contaminants in unwanted places throughout the building. Evidence suggests that open (non-filtered) exhaust fans have also released contaminants from the interior of the building to the environment for decades. PCBs, asbestos insulation, and chipping/flaking lead-based paint are also found deposited throughout the building.

Facility Y9401-2 (Plating Shop) received four category scores of 4, one category score of 5, and a total of 25. All of these scores relate to a variety of chemical contamination issues.

Facility Y9213 (Criticality Experiment Facility) received two category scores of 5, and a total of 24. This facility was built in 1951 and contains two underground neutralization tanks and an underground pit. The tanks and pit present a very high potential for radiological and chemical soil contamination. The areas around the tanks have not been sampled for contamination. The facility also exhibits extensive flaking of exterior lead-based paint.

Facility Y9743-2 (Animal Quarters) received two category scores of 5, and a total of 20. These scores reflect the uncertainty associated with the lack of radiological and chemical sampling surveys, the complete lack of institutional and process knowledge and, the fact that there are interior tanks and bottles with unknown contents. The probability of biological and chemical contamination is high. There is also a total lack of facility maintenance.

Facility Y9203 (Instrumentation, Characterization Department and Manufacturing Technology Development Center) has three category scores of 4 and a total score of 22.5. Despite much work that has been done to re-route process drains from terminating in the storm sewer system, these drains now go to the sanitary sewer system. This termination still presents a potential pathway to the environment and the public.

Facility Y9769 (Analytical Services Organization) has three category scores of 4 and a total score of 21. The primary hazards associated with this facility are related to the wide variety of toxic materials maintained in the laboratory and the building's drain destination. Exit drains go to the Oak Ridge Sewage Treatment Facility and therefore represent a pathway for contaminants to the city's effluent and/or sludge. Also, the sub-basement area is posted as a contamination area and confined space. Failure of containment could cause a release to East Fork Poplar Creek or to the atmosphere.

Facility Y9201-3 (Alpha 3) received one category score of 5, and a total of 20. This facility is not receiving any maintenance on its exterior painted surface. Lead based paint is chipping and is being spread extensively around the building.

Facility Y9738 received two category scores of 4, and a total of 17. This building contains foundry machinery and furnaces and spaces that are chemically and radiologically contaminated from past operations. It is assumed that some of this material has moved into the floor drain system. There is also extensive exterior paint peeling. There was a very limited knowledge of process history available to staff.

Facilities Y9210, Y9211, Y9224 (ORNL Biology) each had one category score of 4 with a total score of 11 for each facility. The original concern regarding each of these facilities was the questionable terminal destinations of their exit drains, which in some cases historically went to the storm sewer system. Written confirmation from the DOE contractor has since shown the correct terminations and corrective actions taken on some of these drains, but there are still undefined and/or inappropriate drain terminations (i.e. lab drains that terminate at the sanitary sewer).

Facility Y9207 Biology Complex received one category score of 4, and a total score of 13. In this facility the sinks in a radiological area drain directly to the Oak Ridge sewer system, and thus represent a potential pathway for radiological materials to the city sewage and sludge.

Facility Y9959-2 Storage Facility received one category score of 4, and a total score of 6. The exterior paint is no longer in a stable matrix and is being spread to the environment.

At **ETTP** six facilities had at least one category score of four or five: K1037-C, K633, K1200-S, K1004-J, K1220-N, and K1401L3.

Facility K1037-C (Nickel Smelter House) received five category scores of 5, one category score of 4, and a total of 29. This is an old facility in general disrepair. It has numerous roof leaks and is heavily contaminated, both radiologically and chemically. Large scrubber-type vessels located on the East End of the second floor of the barrier production area contain internal radioactive contamination. Discarded contaminated equipment is stored in the building. The facility is posted as a PCB hazard. No corrective actions have been completed at this facility.

Facility K633 received five category scores of 5, and two category scores of 4. There is extensive radiological contamination throughout the building, and extensive peeling exterior and interior paint, which contain PCBs, asbestos, and lead. External soil contamination suggests radiological material has moved to the environment.

Facility K1200-S (Centrifuge Preparation Laboratory, South Bay) received two category scores of 4 and a total score of 26.5. The high score is primarily attributable to the uncertainty of radiological contamination associated with the ventilation system. The interior ductwork and portions of the roof where air is exhausted have not been surveyed for contamination. The potential for airborne release appears great. Equipment inside the facility contains uranium hexafluoride and other hazardous chemicals, and there are numerous radiologically contaminated storage areas. Confined space entry requirements prevented the division from performing a survey of the pits below the centrifuges. The greatest release potential for contaminants would be during decontamination and decommissioning activities. *Equipment removal and cleanup is ongoing at this facility. It is expected that the facility will in the future be removed from the division's "high rankers" list.*

Facility K1004-J received two category scores of 5, one category score of 4, and a total of 19. This facility was constructed in 1948 and was originally used for uranium recovery from spent fuel solutions and centrifuge research. It originally included a hot cell, reinforced concrete vaults, and a 750 gallon "hot" tank, a 5,500 gallon underground Low Level Liquid Waste tank, and a laboratory. The facility was ranked high in the PER database because of the poor state of knowledge concerning facility infrastructure. First, there is considerable uncertainty over the location and number of active storage vaults under the facility. It is also unknown whether any of these vaults contain radioactive materials or contamination. There is also considerable uncertainty over drainpipe connections and their contribution of radiological and chemical contaminants to general area contamination. No corrective actions have been completed at this facility.

Facility K1220-N (Centrifuge Plant Demonstration Facility, North) received one category score of 4 and a total score of 18. The interior ductwork has not been surveyed for radiological contamination and the score reflects a high degree of uncertainty concerning the presence of radionuclides. Uranium residuals are present inside the centrifuge systems. After the centrifuge systems are removed and the criticality and security concerns are addressed, this facility is a candidate for reuse. No corrective actions have been conducted at this facility.

Facility K1401L3 received one category score of 4, and a total score of 15. This ranking was given because of extensive radiological contamination that encompasses the building and housed equipment. There are also suspect contaminated areas that have not been surveyed, such as the areas above eight feet.

At **ORNL** twenty five facilities had at least one category score of four or five: 3026, 3517, 3028, 3019-B, 3001, 7700, 7700C, 7701, 7706, 7707, 7720, 7700B, 2545, 3504, 2531, 3592, 3002, 3020, 3108, 3091, 3085, 7602, 3517, and 7055.

Facility X3026 received seven category scores of five, one category score of 4, and a total score of 44. These scores reflect the fact that the physical integrity of this building is severely compromised. The entire facility is a radiological contamination zone, and it contains two banks of four-each contaminated hot cells. Roof holes and broken windows allow the free flow of rainwater and wildlife in and out, and the potential for environmental release of contaminants along this pathway is great. The high level of moisture in the building (from rainwater intrusion) has resulted in mold levels so high that the building is now a designated respirator area. The liquid low level waste line to which the building is attached has leaked and contributed to soil contamination at the northwest corner of the facility.

Facility X3517 received five category scores of five, one category score of 4, and a total score of 39. Despite these relatively high scores, the physical condition of this facility is good, and much effort has gone into decontamination and cleanup work inside the facility. Still, breaches in containment/process systems in the facility resulted in low levels of radiological contamination being distributed throughout. The liquid low level waste system has contributed radiological contamination to the soil and groundwater outside the building.

Facility X3028 received two category scores of five, five category scores of 4, and a total score of 36. The primary issue with this facility was the relatively large source term of radiological contamination distributed throughout the building. It also shows extensive peeling and chipping of interior wall paint that is supposed to serve as containment for plutonium contamination. Ongoing corrective actions are occurring at this facility.

Facility X3019-B (High Level Radiation Analytical Laboratory) at ORNL has four category scores of 4, one category score of 5, and a total score of 33. The primary concern with this facility is the very high levels of radiological contamination. The eight hot cells in this facility are "Very High Radiation Areas" and contain many different radionuclides from past operations. The in-cell steam pipes, the off-gas ventilation system, and the ventilation ductwork on the roof are also radiologically contaminated. Also, the Laboratory Off-Gas ductwork located above the hot cells contains perchlorates six times above the maximum recommended by the ORNL Perchloric Acid Committee Corrective. Perchlorates are shock sensitive and have the potential to react violently when disturbed. Signage identifying this hazard is posted, and the situation was recently upgraded from an "Off-normal" to an "Unusual Occurrence."

Facility X3001 (Graphite Reactor) at ORNL has two category scores of 4, and a total score of 28. The primary concern with this facility is that there is considerable radiological contamination. The air exhaust shaft that vented the reactor pile is contaminated with cesium-137, strontium-90, and fission products. This is a source releasable to the outside environment if a fire or other event occurred in the ventilation system. Several corrective actions, such as the plugging of drains that went to the sewer system, were recently implemented at this facility.

Facilities X7700, 7700C, 7701, 7706, 7707, 7720, 7700B (Towers, scrapyard, above-ground storage areas, waste storage tank, reactor pool, heat exchanger bldg., battery house, civil defense bunker, below-ground outside source storage area) are all part of the Tower Shielding Complex. A survey of this group of facilities resulted in two category scores of 5, and 14 category scores of 4. The primary issues at this complex of facilities are: soil contamination, uncovered activated and contaminated equipment and material, and drain lines that have direct connections to the environment. Ongoing corrective actions are being carried out at this facility.

Facility X2545 (Coal Yard Runoff Collection Basins) at ORNL has one category score of 5, two category scores of 4, and a total score of 21. Orphaned, 2- and 6-inch diameter, cast iron Low Level Liquid Waste (LLLW) lines run through the facility property, and a LLLW line box is posted as a radiation area. The area has been chained off and is overgrown with vegetation. Due to the radiological postings, the cast iron LLLW lines are assumed to be degraded and leaking to the environment. ORNL Environmental Restoration staff has been notified of these lines and their condition, but TDEC has not received written confirmation concerning corrective actions.

Facility X3504 (Geosciences Lab.) received one category score of 5, one score of 4, and a total of 20. The entire building is a posted contamination area. There is also underground and soil contamination outside of the building.

Facility X2531 (Radiological Waste Evaporator Facility) received one category score of 5, one score of 4, and a total 21. This ranking includes #2537 (Evaporator Pit) and #2568 (HEPA filter bldg.). Even though this is a relatively clean, modern facility, it earned these scores because of several areas of transferable radiological contamination, and high radiological dose rates surrounding the evaporator pit.

Facility X3592 (Coal Conversion Facility) received two category scores of 4, and a total of 27. Its original mission was to explore the potential for utilizing liquefied coal as an alternative fuel source. But in later years the facility performed lithium isotope separation using massive quantities of mercury. The scores were given for transferable radiological contamination and mercury contamination in the drains.

Facility X3002 (HEPA Filter House for the Graphite Reactor) has one category score of 4, and a total score of 18. The primary hazards associated with this building are related to the high level of airborne and other radiological contamination in the roughing filter room, the HEPA filter bank, and the ventilation system. Several corrective actions that were recommended by the division were implemented at this facility.

Facility X3020 (Radiological stack for bldg. 3019A-B) received three category scores of 5, and a total score of 18. All of the major concerns noted for this facility were related to legacy features that are not part of the present-day operational infrastructure. There is an antiquated, contaminated drain line that was part of the ORNL LLLW system. This line leaked and contributed to surface and subsurface contamination of the general area from the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing contamination. There is also a contaminated, above-grade, single-walled concrete sump box attached to the floor drain system.

Facilities X3108 and 3091 (HEPA filter houses for buildings 3019A-B and Radiological Stack 3020) each received three category scores of 5. 3108 received a total score of 23, and #3091 received a total score of 25. These two facilities are physically connected to the #3020 stack. And like the 3020 Stack situation described above, all major concerns noted with these facilities are related to their non-operational infrastructure. Associated with both facilities is a contaminated drain system that went to the LLLW system. This line leaked and contributed to general-area surface and subsurface contamination from the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing to contamination. Both facilities also contain significant levels of radiological contamination, considerable contaminated aboveground ductwork, and contaminated lower-level HEPA filter pits. Both facilities are non-state-of-the-art structures that are adequately maintained.

Facility X3085 (Oak Ridge Research Reactor Pumphouse) received one category score of 4, and a total score of 25. This score was based on the possibility for underground leakage of contaminated

water from the 10,000-gallon decay tank, and from the underground valve sump tank located in the
front of the building. Two empty but internally contaminated, aboveground tanks are still tied to underground piping adjacent to the building. Several recommended corrective actions, such as the plugging of floor drains, have been completed at this facility.

Facility X7602 (Integrated Process Development Lab.) received one category score of 4, and a total score of 17. The primary concern with this building was the extensive transferable radiological contamination throughout the facility.

Facility X7055 (Storage Bldg.) scored one category score of 4, and a total score of 7. The only concern with this building was that it has a floor drain system that is connected directly to the outside yard. Even though the building has changed missions and several corrective actions have been implemented, it still contains hazardous materials.

Conclusion

The historic release of chemical and radiological materials from buildings and other facilities on the Department of Energy's Oak Ridge Reservation has led to elevated levels of contaminants in regional terrestrial and aquatic ecosystems. In an effort to understand more about the sources of these contaminants, the division investigates the historic and present-day potential for release of contaminants from facilities through its Facility Survey Program. During its twelve-year history the program has examined 176 facilities and found that thirty six percent (64) pose a relatively high potential for release of some contaminant to the environment. In many cases legacy contamination from degraded facility infrastructure, such as underground waste lines, or substandard sumps and tanks, or ventilation ductwork, will drive high scores until antiquated facilities are fully remediated. This is particularly the case at Oak Ridge National Laboratory where many facilities were connected to an aging low-level liquid waste line system. Inactive facilities that are no longer receiving adequate exterior or interior maintenance are also driving high scores. On many buildings, peeling lead-based paint is extensive, and will only get worse as time passes, if not remediated. Accelerated infrastructure reduction programs that began at Y-12 and ORNL in 2002, and at ETTP in 2003 are alleviating some of these problem areas.

When facility concerns are noted by the division they are relayed to the Department of Energy via the Facility Survey Report so that corrective actions can be formulated. To date, many corrective actions have occurred, and ten facilities have been removed from the division's list of high Potential Environmental Release facilities. Those concerns that have not been corrected to the extent that the division has reduced the Potential Environmental Release score to less than a "4" are reflected in this report. The rankings are changed when written documentation is received by the division from DOE. And, since the evaluation of corrective actions is an ongoing, time-consuming process, present scores may in some cases not reflect the most recent completed corrective actions.

References

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. 1994-05. Facility Survey Files.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee.

Thomasson, D.A., 2005. Health, Safety, and Security Plan. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

U.S. Department of Energy. *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to Their Environmental Consequences.* 1997. U.S. Department of Energy, Office of Environmental Management. Oak Ridge, Tennessee.

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CHAPTER 5 RADIOLOGICAL MONITORING

Walkover Radiological Surveys

Principal Authors: Chris Yarnell, Robert Storms

Abstract

The Oak Ridge Reservation (ORR) was placed on the National Priorities List (NPL) in 1989. The purpose of Footprint Reduction was to identify portions of the ORR that have not been environmentally impacted by past federal (Department of Energy - DOE) activities. The mission was to determine which land parcels could be conditionally released from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. CERCLA 120-(h) was used as the guideline by the footprint team for the footprint investigations.

The goal was further identified as reducing the size and configuration of the area of the ORR designated as part of the NPL site and determining a No Further Investigation (NFI) status. This current project was to revisit these sites to determine if action had in fact been taken by DOE to rectify the problems and other division concerns. Official site visits were not performed as a routine manner for calendar year 2005. Unfortunately, due to budgetary cutbacks or prioritization changes on DOE's part, none of the maintenance action sites have received the requested attention or response.

The haul road segment of the project began in 2005 as an oversight of the transport/hauling of radioactive materials on haul roads on the Oak Ridge Reservation (ORR). This oversight activity was generated due to a response to a spill of radioactive materials on a portion of Bear Creek Valley Road. After this spill occurred, haul roads were built in order for the radioactive materials to be transported to the new EMWMF waste cell in Bear Creek Valley without traveling on public roads. In 2005, the division conducted bi-monthly walkover surveys of Reeves Road, Flannigans Loop Road, and a portion of Lagoon Road. This project will expand as more haul roads are utilized and/or areas where the potential for radioactive contamination and transport are identified.

Introduction

The Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) with the cooperation of the U.S. Department of Energy and its contractors conduct periodical walkover surveys of radiological waste haul roads located within the ORR for the purpose of evaluating the potential of spills and/or leakage of radioactive materials during transport. This program is in response to a radioactive spill that occurred on Bear Creek Valley Road. As a result of this spill, Bear Creek Valley Road was repaved and made into a secured road. The division, in an effort to protect the environment and the citizens of the State of Tennessee, has decided to survey radioactive material haul/transport roads on the ORR. As of 2005 there are two haul roads that are currently being surveyed bi-monthly, they are Reeves Road (ORNL to EMWMF) and Flannigans Loop Road (a portion of the haul road from ETTP to EMWMF, the entire road will be open to traffic in early 2006). Both of these haul roads will continue to be surveyed bi-monthly throughout 2006. Walkover surveys are also conducted on an "as needed" basis on other roads within the ORR. For 2005, this included the walkover survey of a portion of Lagoon Road. This road was added to the walkover survey list due to the high construction traffic flow from Melton Valley (an area known to contain radiological contamination in the subsurface) onto Bethel Valley Road and ultimately onto Highway 95 (a publicly driven road not located on the ORR). Under a modified DOE Order 5400.5, any areas exceeding 200dpm/100cm2 removable beta, 1000dpm/100cm2 total beta, 20dpm/100cm2 removable alpha, and 100dpm/100cm2 total alpha would require remediation. These values are conservative based on the actual DOE Order 5400.5 for these contaminants.

A field log is produced for each walkover survey and a copy is placed in the files at the division's office. If any anomalous data is collected during the walkover survey, the information is directed toward the TDEC Radiological Monitoring and Oversight Manager and the corresponding DOE officials are contacted.

Methods and Materials

Procedures employed during the project are consistent with those contained in the TDEC DOE-O Work Plan for the Walkover Survey Program for field radiological surveys. The walkover surveys are conducted using a physical approach. The area is researched prior to surveying in order to know what type of radioisotopes will be most common to the area. The road is first driven from end to end to determine the lay of the land. From there, a walkover is conducted with the use of a sodium iodide (gamma) detector. Other radiological instruments are on hand as necessary. These include Geiger-Muller Pancake (beta) detectors, Zinc-Sulfide (alpha) scintillator, Bicron MicroRem (tissue dose equivalence), and in-situ gamma spectrometer for isotope identification. Areas with staining of soil and/or stressed vegetation are noted for sampling.

The walkover surveys also allow us to visually inspect the roads for erosion and to look for any trash/garbage/debris that may be on or along side of the haul road. When the surveyors observe instances such as this, they are noted in the field log, surveyed if possible, and the information passed on to the appropriate managers.

If suspect areas are found, staff collect the area location with the use of a global positioning system (GPS). Areas of concern, as well as other points, are logged to show coverage. A field log is generated each trip with the state's findings. Concerns are brought to the attention of the Federal Facility Agreement (FFA) and/or the Tennessee Oversight Agreement (TOA) Project Managers for resolution

Results and Discussion

The objective of this oversight activity is the detection of radionuclides that may be leaked and/or spilled on radiological transport/haul roads on the ORR. The 2005 objective consisted of bi-monthly surveying Reeves Road and Flannigans Loop Road. A portion of Lagoon Road was added to the bi-monthly survey during a time of heightened construction activity in the area. The division generates a field log for each site during the walkover survey. The purpose of the oversight activity is to determine the presence of any radionuclides located on the transport/haul roads.

One location on the south end (ORNL side) of Reeves Road was found to contain elevated gamma readings. This reading was collected prior to current haul road activity. The pertinent TOA manager was contacted and the area has subsequently been chorded off and marked as a radiological contaminated area. To date, this has been the only area found that required FFA/TOA Project Manager attention. Future work will consist of continuing the walkover surveys until the haul roads are no longer in use.

Conclusions

The continued use of the radioactive material transport/haul roads will require the state's continued bi-monthly walkover surveys in order to adequately determine the presence or lack of any radionuclides. The 2006 plan will be to further investigate the ORR haul roads and evaluate the potential for new pathways for any radionuclides to reach public roads from the ORR. The Footprint Reduction process will be ready for additional surveys when DOE raises its priority or their budgetary cutbacks have been lifted.

References

Federal Facility Agreement, January 1992 (with revisions).

FRMAC. 1998. *FRMAC Monitoring and Sampling Manual, Vols. 1 & 2*. DOE/NV/11718-181-Vol. 1 & Vol. 2. Federal Radiological Monitoring and Assessment Center, Nevada Test Site. http://www.nv.doe.gov/programs/frmac/DOCUMENTS.htm

Tennessee Department of Environment and Conservation, *Tennessee Oversight Agreement. Agreement between the U.S. Department of Energy and the state of Tennessee.* Oak Ridge, Tennessee 2001.

Thomasson, D.A. 2005. *Health, Safety and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

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CHAPTER 5 RADIOLOGICAL MONITORING

Surplus Material Verification

Principle Author: John McCall

Abstract

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division's (the division) Radiological Monitoring and Oversight Program conducted random radiological monitoring of surplus material offered for sale to the public. A total of 13 inspection visits were conducted at the Oak Ridge Reservation (ORR) facilities. No sales were conducted at the ETTP facility. Four items were observed that required further evaluation. Three of these items had measurable radioactivity.

Introduction

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division), in cooperation with the U.S. Department of Energy and its contractors, conducts random radiological surveys of surplus materials that are destined for sale to the public on the Oak Ridge Reservation (ORR). In addition to performing the surveys, the division reviews the procedures used for release of materials under DOE radiological regulations. Some materials, such as scrap metal, may be sold to the public under annual sales contracts, whereas other materials are staged at various sites around the ORR awaiting public auction/sale. The division as part of its larger radiological monitoring role on the reservation conducts these surveys to help ensure that no potentially contaminated materials reach the public. In the event that radiological activity is detected, the division immediately reports the finding to the responsible supervisory personnel of the surplus sales program and follows their response to the notification to see that appropriate steps (removal of items from sale, resurveys, etc.) are taken to protect the public.

Methods and Materials

Staff members make random surveys of items that are arranged in sales lots by using standard survey instruments. Inspections are scheduled just prior to sales after the material has been staged. Items range from furniture and equipment (shop, laboratory and computer) to vehicles and construction materials. Particular attention is paid to items originating from shops and laboratories. Where radiological release tags are attached, radiation clearance information is compared to procedural requirements. If any contamination is detected during the on-site survey, the surplus materials manager for the facility is notified immediately.

Results and Discussion

A total of 13 inspections were conducted at ORNL and Y-12. No sales were held at ETTP. Low levels of radiological contamination were discovered on three items during the DOE-O surveys. There were two items observed at the ORNL surplus sales facility that required further evaluation. During an inspection on June 21, 2005, radiation above background levels was detected on the base of a metal stand. The item was removed from the sale by ORNL radiation protection service personnel for further evaluation. In an inspection on September 20, 2005, radiation above background levels was detected on a cabinet shelf. ORNL radiation protection service personnel surveyed the shelf and found it to be within regulatory release limits. As a final precaution, they removed the shelf prior to the auction.

Two observations requiring further evaluation were made at the Y-12 surplus sales facility. In an inspection on March 11, 2005, a radiological release tag indicated that a desk was cleared for release to a protected area. Y-12 radiation protection services personnel were called to change the tag to clear the desk for release to the public. In an inspection on April 6, 2005, alpha contamination was detected on a toolbox. Y-12 radiation service personnel surveyed the toolbox and determined that some radiological contamination was present. The contamination was below regulatory requirement for release to the public so the item remained in the sales inventory.

Conclusion

Hundreds of surplus materials items were sold through ORNL or Y-12 surplus sales organizations in separate sales events. The facilities have performed a good job of preventing radiological contamination from reaching the public through their surplus material sales. Minor radiological contamination was detected in only three items. Only two of the items were removed from sales and returned to the submitting group as a final precaution.

References

Tennessee Department of Environment and Conservation. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Environmental Monitoring Plan.* 2005. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the state of Tennessee.* Oak Ridge, Tennessee.

Thomasson, D.A. 2005. *Health, Safety, and Security Plan,* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division, Oak Ridge, Tennessee.

CHAPTER 6 SURFACE WATER MONITORING

Bacteria Levels of East Fork Poplar Creek

Principal Author: Kathleen Kitzmiller

Abstract

East Fork Poplar Creek (EFPC) is currently posted by the state's Division of Water Pollution Control with a bacteriological advisory mandating no water contact. Although in recent years the Y-12 National Security Complex has upgraded its sanitary wastewater treatment system, public health concerns remain that effluent from Y-12 might impact surface water bacteriological levels in the creek. From July 19, 2005, to August 17, 2005, DOE-O personnel collected water samples from ten sites along EFPC. Sampling results for E. coli found that nine sites located directly on EFPC complied with State criteria for recreational water use. However, had the State adopted equivalent criteria for enterococci, none of the sampling sites would have been in compliance. Sampling results both for E. coli and enterococci suggest that relative to other locations on or near EFPC, the Y-12 Plant is not a significant source of bacterial contamination levels in the creek.

Introduction

According to the 2004 305(b) Report, *The Status of Water Quality in Tennessee*, roughly 3,166 stream miles in Tennessee are currently impaired for E. Coli and 1,710 stream miles for Fecal Coliform while 32 streams and rivers (147 river miles) are posted for no water contact due to high bacterial levels. East Fork Poplar Creek (EFPC) has a bacterial advisory from its mouth to Mile 15.0. Generally, sources of fecal bacteria contamination to surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and urban runoff.

The Y-12 National Security Complex discharges treated wastewater from its sewage treatment plant into East Fork Poplar Creek (EFPC). In recent years, Y-12 has upgraded its sanitary wastewater treatment system. However, public health concerns remain that effluent from Y-12 may impact surface water bacteriological levels in EFPC. Results from this bacteriological sampling of EFPC do aid TDEC/DOE-O in addressing whether Y-12 is a significant contributor to fecal bacteria contamination levels in the creek.

Because they are commonly found in human and animal feces, members of two bacteria groups, coliforms and fecal streptococci, serve as indicators of possible sewage contamination. Although usually not harmful themselves, they indicate the presence of pathogenic bacteria, viruses, and protozoans that also live in human and animal digestive systems. Many states still use the pre-1986 standard for fecal coliform as the numeric criterion to protect recreational uses of water. Studies conducted by the EPA suggest that the best indicators of health risk from recreational water contact in fresh water are E. coli and enterococci. E. coli is a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. A subgroup of the fecal streptococcus group, Enterococci are typically more human-specific than the larger fecal streptococci group. The EPA recommends that states transition to the E. coli and enterococci criteria because these bacteria indicators correlate more closely to gastrointestinal problems than the fecal coliform indicator. Effective January 7, 2004, the state of Tennessee adopted the E. Coli criterion.

Bacteriological samples of surface water were collected at ten locations along EFPC listed below (Figure 1). The sites follow EFPC from Station 17, where EFPC leaves the Oak Ridge Reservation, to the river mile 6.3 Biological Monitoring and Abatement Program (BMAP) monitoring site at the bridge crossing on Highway 95. Intermediate sites along the course of EFPC, and one site along an EFPC tributary near downtown Oak Ridge, were selected on the basis of proximity to potential sources of bacteriological contamination.

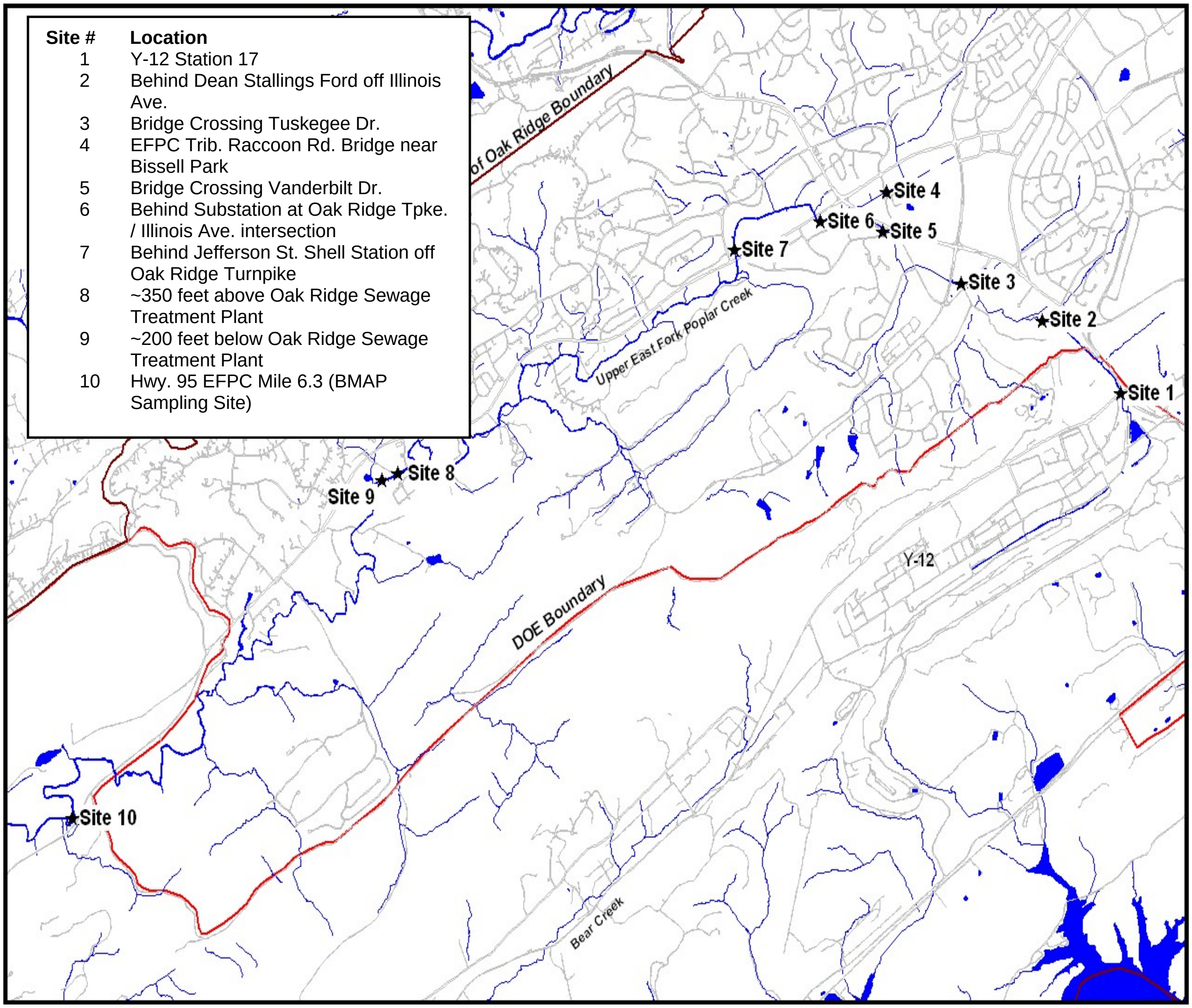


Figure 1 Bacteriological Sample Locations Map

Methods and Materials

Parameters
E. coli, Enterococci

Procedure Background
The current Tennessee General Water Criteria (Rule 1200-4-3-.03) for surface water state that for recreational use, the concentration of the E. coli group shall not exceed 126 colony-forming units (CFUs) per 100 ml, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 ml shall be considered as having a concentration of 1 per 100 ml. The State's water criteria set a single sample maximum density of 941 CFUs of E.coli per 100 ml. The geometric mean limit corresponds to a predicted illness rate of 8 per 1,000, while that for the single-sample maximum corresponds to an illness rate of 10 per 1,000.

Several states have adopted fresh water enterococci criteria. For a predicted illness rate of 8 per 1,000, EPA guidance for fresh recreational water calls for a geometric mean of no more than 33 CFUs of enterococci per 100 ml. For an illness rate of 10 per 1,000, EPA guidance sets a single sample maximum density of 246 CFUs of enterococci per 100 ml.

Schedule
DOE-O staff gathered five sets of bacteriological samples from all ten EFPC sites over a thirty-day period extending from July 19, 2005, to August 17, 2005. Hot and dry weather conditions prevailed during this time frame.

Procedure Overview
DOE-O staff collected grab-samples from each sampling location. Within a thirty-day timeframe, DOE-O personnel collected five sets of grab samples of surface water from nine locations along and one location near EFPC. DOE-O personnel compiled analytical results and calculated for each sampling site geometric means for both parameters. A clean pair of disposable latex or vinyl gloves was worn each time a different location was sampled. Gloves were donned immediately prior to sampling. At each location, a grab sample was collected in a 100 ml sterile plastic, bacteriological sampling bottle. Samples were stored on ice at the time of collection. Care was taken to ensure that the sample containers did not become submerged beneath melted ice, as this might have resulted in the cross-contamination of samples.

Laboratory Procedures
The Tennessee Department of Health, Environmental Laboratory and Microbiological Laboratory Organization (Laboratory Services) provided analytical services to the TDEC DOE-O. The Knoxville branch of Laboratory Services analyzed the bacteriological samples following appropriate methods detailed in *Standard Methods for the Examination of Water and Wastewater,* 20th edition.

Results
The EFPC study focused upon assessing the relative impact of Y-12 Plant operations upon two parameters: E. coli and enteroccoccus.

E. coli

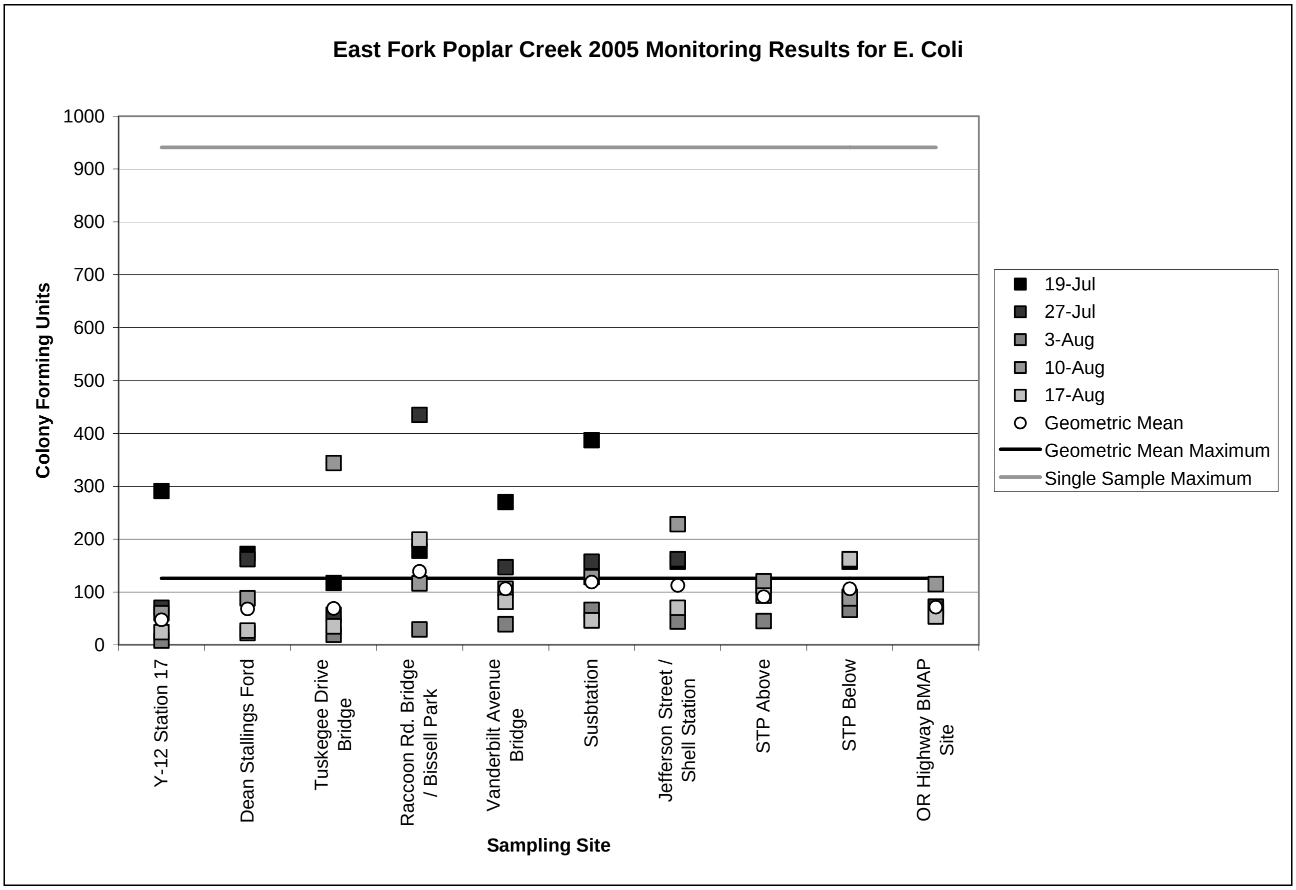
Table 1 and Figure 2 present the sampling results for E. coli. Values that exceeded limits are shaded gray in the table. Geometric means for all nine sampling sites located directly along EFPC fell below the 126 CFU limit for E. coli. However, samples collected from the tributary to EFPC at the Raccoon Road Bridge near Bissell Park yielded at geometric mean of 139 E. coli CFUs, exceeding the limit. Samples collected from Station 17 at Y-12 resulted in a geometric mean of 47 E. coli CFUs, the lowest level of all ten sampling locations. No individual samples exceeded the single sample maximum density limit of 576 E. coli CFUs.

Table 1:

East Fork Poplar Creek Bacteriological Sampling Results for E. Coli

	Colony-Forming Units					
Sampling Location	7/19	7/27	8/03	8/10	8/17	Geo. Mean
Y-12 Station 17	291	70	8	60	24	47
Dean Stallings Ford	172	162	22	88	27	68
Tuskegee Drive Bridge	117	57	19	344	35	69
Raccoon Rd. Bridge / Bissell Park	178	435	29	116	199	139
Vanderbilt Avenue Bridge	270	147	39	106	81	106
Susbtation	387	157	66	128	46	119
Jefferson Street Shell Station	157	162	44	228	70	112
STP Above	111	111	45	120	93	91
STP Below	157	91	66	88	162	106
OR Highway BMAP Site	67	72	62	115	54	71

Figure 2:



Enterococci

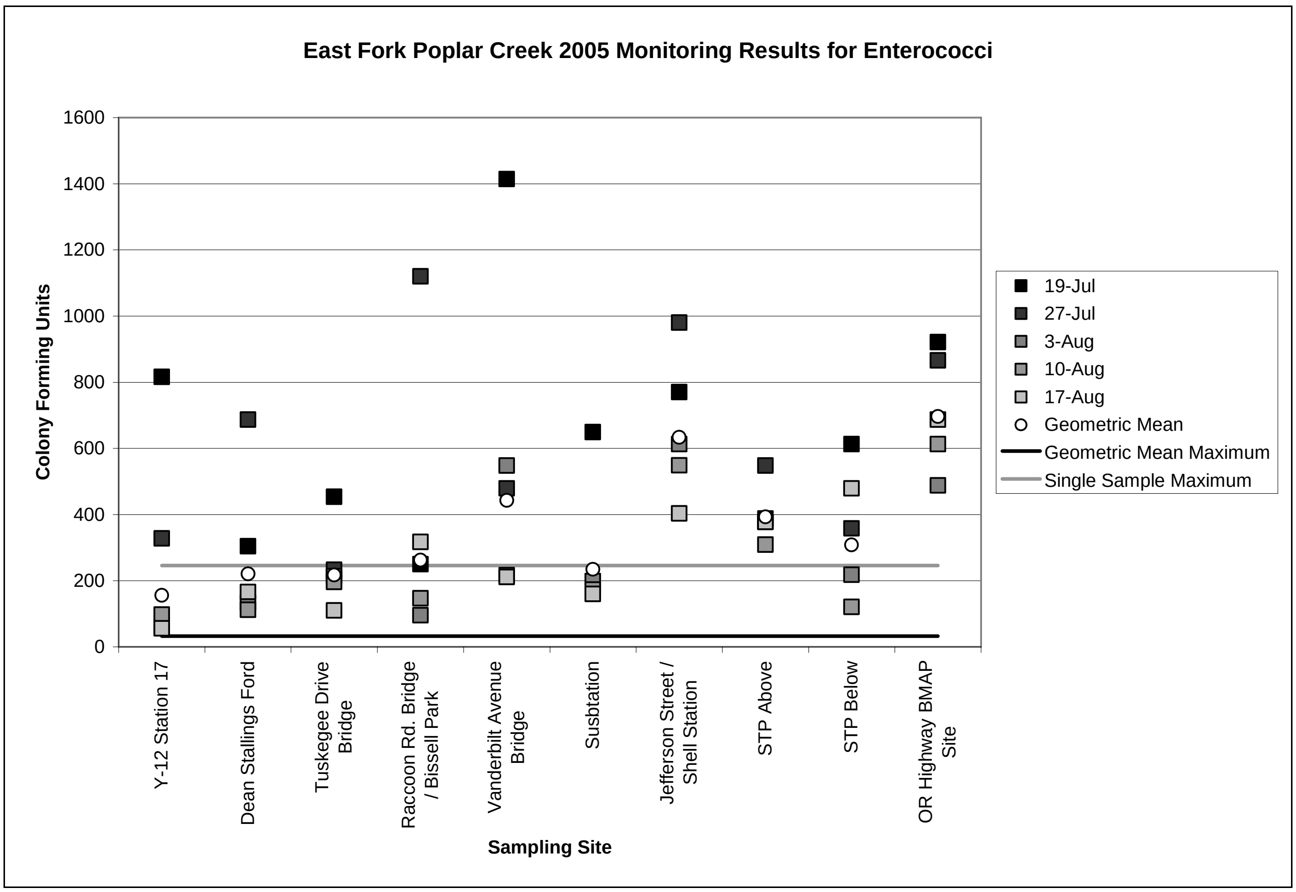
Table 3 and Figure 2 present the sampling results for enterococci. Values that exceeded EPA guidance limits are shaded gray in the table. Geometric means for all ten sampling sites exceeded 33 CFU for enterococci. Samples collected from Station 17 at Y-12 resulted in a geometric mean of 156 enterococci CFUs, the lowest level of all ten sampling locations. Of the fifty individual samples collected for the study, thirty (60%) exceeded a single sample maximum density limit of 246 CFUs for enterococci.

Table 2:

East Fork PoplarCreek Bacteriological Sampling Results for Enterococci

	Colony-Forming Units					
Sampling Location	**7/19**	**7/27**	**8/03**	**8/10**	**8/17**	**Geo. Mean**
Y-12 Station 17	816	328	63	98	56	156
Dean Stallings Ford	304	687	134	112	166	220
Tuskegee Drive Bridge	454	233	214	196	110	218
Raccoon Rd. Bridge / Bissell Park	250	1120	96	147	317	263
Vanderbilt Avenue Bridge	1414	479	548	217	211	443
Susbtation	649	198	199	173	160	234
Jefferson Street Shell Station	770	980	613	549	403	634
STP Above	388	548	378	309	378	393
STP Below	613	358	218	121	479	308
OR Highway BMAP Site	921	866	488	613	687	697

Figure 3:



Conclusion

With respect to E. coli, all nine sampling sites located directly on EFPC were in compliance with Tennessee General Water Criteria for recreational use of surface water for this sampling campaign. This sampling campaign was conducted during a hot and dry weather conditions and alone does not justify a decision on discontinuation of bacteriological advisory. Should rigorous bacteriological sampling of EFPC conducted by the City of Oak Ridge under more diverse weather conditions also meet State criteria, the continued posting of EFPC would no longer appear to be warranted.

Sampling results both for E. coli and enterococci suggest that relative to other locations on or near EFPC, the Y-12 Plant is not a significant source of fecal bacteria contamination levels in the creek. However, the sampling results for enterococcus indicate the need to identify and remedy the sources of fecal bacteria contamination in EFPC. At some future date the State of Tennessee may adopt enterococci-based water quality criteria. If so, bacteriological posting may continue to be necessary.

References

Eaton, A.D., L.S. Clesceri, and A.E. Greenberg, editors. 2000. *Standard Methods for the Examination of Water and Wastewater,* 20th edition. American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, DC.

Tennessee Department of Environment and Conservation. *General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee.* (Rule 1200-4-3-.03). Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Tennessee Department of Environment and Conservation. 2004. *2004 305(b) Report: The Status of Water Quality in Tennessee*. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement. Agreement between the U.S. Department of Energy and the state of Tennessee.* Oak Ridge, Tennessee. 2001.

Thomasson, D.A.. 2005. Health, Safety, and Security Plan. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

United States Environmental Protection Agency. 2002. *Consolidated Assessment and Listing Methodology: Toward a Compendium of Best Practices*. United States Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. Washington, D.C.

United States Environmental Protection Agency. 2002. *Implementation Guidance for Ambient Water Quality Criteria for Bacteria*. United States Environmental Protection Agency, Office of Water. Washington, D.C.

United States Environmental Protection Agency. 1997. *Volunteer Stream Monitoring: A Methods Manual*. United States Environmental Protection Agency, Office of Water. Washington, D.C.

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CHAPTER 6 SURFACE WATER MONITORING

Rain Event Surface Water Monitoring

Principle Author: Roger Petrie

Abstract
The DOE Oversight Division conducted surface water sampling at six sites on the Oak Ridge Reservation (ORR) in 2005. Samples were collected once per quarter following a qualifying rain event. Most results were consistent with results from a non-contaminated site following a heavy rain. One exception was elevated radiological results from Melton Branch. Results here were elevated due to remedial activities taking place in Melton Valley. Weekly sampling at this site was conducted in order to monitor these levels.

Introduction
Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for contamination to impact surface waters on the ORR during heavy rain events. These events could cause the displacement of contamination that would not normally impact streams around the ORR.

To assess the degree of surface water impact caused by these rain events, a sampling of streams will be conducted following heavy rain events to determine the presence or absence of contaminants of concern. Table 1 shows locations that have been selected for sampling.

Table 1. Sample Locations

Site	Location
EFK 23.4	Station 17
WCK 3.0	White Oak Creek at Lagoon Road
MEK 0.1	Melton Branch Weir
MIK 0.1	Mitchell Branch Weir
BCK 4.5	Bear Creek Weir at Hwy. 95
MBK 1.6	Mill Branch (Reference)

Methods and Materials
Once per quarter, surface water samples were collected from the selected sites following either a 1" rain event in a 24-hour period or a 2" rain event in a 72-hour period. Samples were analyzed for the following parameters.

Inorganics: arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, zinc, nitrogen (NO_2 & NO_3), ammonia, nitrogen (total Kjeldahl), total phosphates
Other tests: E. coli, Enterococcus, dissolved residue, suspended residue, and total hardness
Radionuclides: Gross alpha, gross beta, gamma radionuclides

The dates of collection are shown in Table 2 along with the amount of rainfall received.

Table 2. Dates of Collection and Amounts of Rainfall

Date	Rainfall
2/14/05	1.1"
6/20/05	1.27"
11/16/05	1.18"

No sampling occurred during the third quarter of 2005, due to the lack of a qualifying rain event.

Results

Laboratory results for the fourth quarter sampling have not yet been received. This is indicated in the following tables by the "No Data" term. An addendum to this report will be complete once these results are received.

Results of the microbiological analysis of the samples were as expected for samples taken following a rain event. High levels of E. coli and Enterococcus were observed. The results are shown in Table 3.

Table 3. Results of Microbiological Analysis

Site	Date	E. Coli	Enterococcus
		cfu/100mL	cfu/100mL
EFK 23.4	2/15/05	20	19
WCK 3.0	2/15/05	102	42
MEK 0.1	2/15/05	24	21
BCK 4.5	2/15/05	52	11
MIK 0.1	2/15/05	115	62
MBK 1.6	2/15/05	158	<1
EFK 23.4	6/21/05	687	103
WCK 3.0	6/21/05	921	770
MEK 0.1	6/21/05	2419	2419
BCK 4.5	6/21/05	387	1553
MIK 0.1	6/21/05	2419	2419
MBK 1.6	6/21/05	411	2419
EFK 23.4	11/17/05	No Data	No Data
WCK 3.0	11/17/05	No Data	No Data
MEK 0.1	11/17/05	No Data	No Data
BCK 4.5	11/17/05	No Data	No Data
MIK 0.1	11/17/05	No Data	No Data
MBK 1.6	11/17/05	No Data	No Data

Results of the routine parameters were also as expected for samples taken following a rain event. The results are shown in Table 4.

Table 4. Results of Routine Parameters Analysis

Site	Date	Hardness	Residue, dissolved	Residue, suspended
		(mg/L)	(mg/L)	(mg/L)
EFK 23.4	2/15/05	157	184	U
WCK 3.0	2/15/05	139	162	U
MEK 0.1	2/15/05	112	122	U
BCK 4.5	2/15/05	105	112	11
MIK 0.1	2/15/05	136	150	U
MBK 1.6	2/15/05	65	68	U
EFK 23.4	6/21/05	156	168	17
WCK 3.0	6/21/05	166	224	U
MEK 0.1	6/21/05	225	254	27
BCK 4.5	6/21/05	191	175	U
MIK 0.1	6/21/05	185	194	U
MBK 1.6	6/21/05	142	135	U
EFK 23.4	11/17/05	No Data	No Data	No Data
WCK 3.0	11/17/05	No Data	No Data	No Data
MEK 0.1	11/17/05	No Data	No Data	No Data
BCK 4.5	11/17/05	No Data	No Data	No Data
MIK 0.1	11/17/05	No Data	No Data	No Data
MBK 1.6	11/17/05	No Data	No Data	No Data

U – indicates that the analyte was analyzed for but not detected.

The results for nutrient analysis were also as expected for samples taken following a rain event. The results are shown in Table 5.

Table 5. Results of Nutrient Analysis

Site	Date	Ammonia (mg/L)	NO2 & NO3 (mg/L)	Total Kjeldahl (mg/L)	Phosphorus (mg/L)
EFK 23.4	2/15/05	0.05	2.2	0.16	0.08
WCK 3.0	2/15/05	0.05	1.2	0.1	0.06
MEK 0.1	2/15/05	0.04	0.28	0.24	0.07
BCK 4.5	2/15/05	0.08	1.2	0.21	0.05
MIK 0.1	2/15/05	0.02	0.25	0.07	0.03
MBK 1.6	2/15/05	0.04	0.09	0.1	0.08
EFK 23.4	6/21/05	0.06	2.5	0.18	0.05
WCK 3.0	6/21/05	0.12	2.8	0.24	0.27
MEK 0.1	6/21/05	0.05	0.53	0.24	0.53
BCK 4.5	6/21/05	0.14	2.4	0.44	0.03
MIK 0.1	6/21/05	0.07	0.56	0.24	0.04
MBK 1.6	6/21/05	0.09	0.17	U	0.05
EFK 23.4	11/17/05	No Data	No Data	No Data	No Data
WCK 3.0	11/17/05	No Data	No Data	No Data	No Data
MEK 0.1	11/17/05	No Data	No Data	No Data	No Data
BCK 4.5	11/17/05	No Data	No Data	No Data	No Data
MIK 0.1	11/17/05	No Data	No Data	No Data	No Data
MBK 1.6	11/17/05	No Data	No Data	No Data	No Data

U – indicates that the analyte was analyzed for but not detected.

The results for metal analysis were also as expected for samples taken following a rain event. The only results that were above normal were the mercury levels in the EFK 23.4 samples. This was expected given the levels of mercury contamination present in East Fork Poplar Creek. The results are shown in Table 6.

Table 6. Results of Metals Analysis

Site	Date	Hg (ug/L)	As (ug/L)	Cd (ug/L)	Cr (ug/L)	Cu (ug/L)	Fe (ug/L)	Pb (ug/L)	Mn (ug/L)	Zn (ug/L)
EFK 23.4	2/15/05	0.3	U	U	U	3	146	U	46	13
WCK 3.0	2/15/05	U	U	U	U	2	337	U	20	8
MEK 0.1	2/15/05	U	U	U	U	2	744	U	67	8
BCK 4.5	2/15/05	U	1	U	U	U	847	U	70	2
MIK 0.1	2/15/05	U	U	U	1	3	593	U	88	12
MBK 1.6	2/15/05	U	U	U	U	U	408	U	48	3
EFK 23.4	6/21/05	0.6	U	U	U	3	661	U	71	19
WCK 3.0	6/21/05	U	U	U	U	4	80	U	13	16
MEK 0.1	6/21/05	U	U	U	1	2	1220	1	455	11
BCK 4.5	6/21/05	U	U	U	U	1	123	U	45	12
MIK 0.1	6/21/05	U	U	U	2	3	291	U	139	13
MBK 1.6	6/21/05	U	U	U	U	U	289	U	31	2
EFK 23.4	11/17/05	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
WCK 3.0	11/17/05	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
MEK 0.1	11/17/05	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
BCK 4.5	11/17/05	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
MIK 0.1	11/17/05	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
MBK 1.6	11/17/05	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data

U – indicates that the analyte was analyzed for but not detected.

The results of the gross alpha, gross beta, and gamma radionuclide scan are shown in Table 7. These results are similar to those seen at these sites during non-rain event conditions. The presence of low levels of Cs-137 at the WCK 3.0 site is expected. These levels of Cs-137 also account for the elevated levels of gross beta seen at the site. The one exception is the very high level of gross beta noted at MEK 0.1 on 6/21/05. This sampling event coincided with some heavy construction activity near the site as part of remedial activities in the area. Levels dropped back to preconstruction levels soon afterward.

Table 7. Results of Gross Alpha/Beta and Gamma Radionuclide Analysis

Site	Date	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Cs-137 (pCi/L)
EFK 23.4	2/15/05	14.8 ± 5.0	7.9 ± 3.3	
WCK 3.0	2/15/05	0.4 ± 4.9	105.2 ± 7.3	81.4 ± 4.4
MEK 0.1	2/15/05	-12.4 ± 5.5	368 ± 13	
BCK 4.5	2/15/05	7.6 ± 3.2	7.3 ± 3.1	
MIK 0.1	2/15/05	23.6 ± 5.5	14.5 ± 3.8	
MBK 1.6	2/15/05	1.0 ± 2.2	3.9 ± 2.8	
EFK 23.4	6/21/05	9.6 ± 4.3	4.8 ± 3.2	
WCK 3.0	6/21/05	-2.1 ± 6.5	83.5 ± 6.7	23.7 ± 2.6
MEK 0.1	6/21/05	-125 ± 18	1947 ± 34	
BCK 4.5	6/21/05	17.9 ± 5.1	13.9 ± 3.8	
MIK 0.1	6/21/05	13.8 ± 4.8	8.2 ± 3.4	
MBK 1.6	6/21/05	-0.7 ± 2.3	2.0 ± 2.9	
EFK 23.4	11/17/05	8.8 ± 4.2	5.6 ± 3.1	
WCK 3.0	11/17/05	13 ± 10	119.5 ± 7.9	45.4 ± 3.3
MEK 0.1	11/17/05	-58 ± 14	1134 ± 23	
BCK 4.5	11/17/05	8.9 ± 3.9	5.7 ± 3.1	
MIK 0.1	11/17/05	36.3 ± 8.2	20.5 ± 4.2	
MBK 1.6	11/17/05	1.3 ± 2.9	5.2 ± 3.0	

Sampling at MEK 0.1 continued as a follow-up to elevated levels of Sr-90 detected in 2004. The results of this monitoring are shown in Table 8. The levels of Gross Beta activity and Sr-90 activity appear to have stabilized at levels consistent with those present prior to remedial activities. Due to this stabilization of Sr-90 levels, sampling was discontinued in June of 2005. Some monitoring will be conducted after remedial activities have been completed.

Table 8. Sampling Results from MEK 0.1

Date	Gross β Activity (as pCi/L)	Sr 90 Activity (as pCi/L)
1/11/2005	371 ± 13	115 ± 35
1/18/2005	362 ± 13	136 ± 54
1/24/2005	395 ± 14	122 ± 41
1/31/2005	529 ± 16	191 ± 67
2/7/2005	389 ± 14	154 ± 51
2/14/2005	545 ± 16	198 ± 59
2/15/2005	368 ± 13	129 ± 35
2/22/2005	283 ± 11	93 ± 25
2/28/2005	629 ± 17	229 ± 72
3/7/2005	465 ± 15	159 ± 66.0
3/14/2005	482 ± 15	159 ± 51
3/21/2005	415 ± 14	143 ± 59
3/28/2005	201.8 ± 9.7	67 ± 21
4/4/2005	341 ± 13	127 ± 45
4/11/2005	298 ± 12	126 ± 39
4/18/2005	383 ± 13	149 ± 56
4/25/2005	375 ± 13	148 ± 55
5/2/2005	383 ± 13	127 ± 38
5/9/2005	387 ± 14	123 ± 38
5/23/2005	692 ± 18	301 ± 107
5/31/2005	542 ± 19	185 ± 72
6/6/2005	500 ± 19	134 ± 42
6/13/2005	824 ± 24	171 ± 57
6/20/2005	491 ± 22	107 ± 33
6/21/2005	1947 ± 34	495 ± 160
6/27/2005	675 ± 21	235 ± 95

Conclusion

Overall, the results indicate that, with the exception of Melton Branch, there appears to be no significant movement of contaminants into the sampled streams due to heavy rainfall events. The results of the follow up sampling on Melton Branch indicate that there was a short term insult to the stream in relation to remediation activities, but that completion of construction activities have resulted in a reduction of these levels to a point that is consistent with contaminant levels occurring prior to remedial efforts.

References

Tennessee Department of Environment and Conservation. 1997. *State of Tennessee Water Quality Standards, Rules of the Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3 General Water Quality Criteria, Chapter 1200-4-4 Use Classifications for Surface Waters*. Nashville, TN.

Tennessee Department of Environment and Conservation Department of Energy-Oversight. 1996. *Standard Operating Procedures.* Oak Ridge, Tennessee.

Tennessee Department of Health Laboratory Services. 1999. *Standard Operating Procedures.* Tennessee Department of Health Laboratory Services. Nashville, TN.

Tennessee Department of Environment and Conservation. 1998. *The Status of Water Quality in Tennessee: Technical Report.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, TN.

Thomasson, D. A. 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

U. S. Environmental Protection Agency. Enforcement and Investigations Branch. Region 4. 1997. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM).* Athens, Georgia.

CHAPTER 6 SURFACE WATER MONITORING

Ambient Sediment Monitoring Project

Principle Author: John G. Peryam

Abstract

Sediment analysis is a good way to assess what contaminants have been present in a water body in the past. These contaminants are often incorporated into the clay and organic matter fraction of sediment through mechanisms such as cation exchange capacity and organic functional groups. Sediment samples from several Clinch River and tributary sites were analyzed for inorganics, organics, and radiological parameters. Since there are no federal or state sediment cleanup levels, the data were compared to soil background levels and EPA Region 4 sediment screening levels. Where contaminants are found in sediments, the levels are at such low concentrations that they do not pose a threat to human health.

Introduction

Anthropogenic chemicals and waste materials introduced into aquatic systems often accumulate in sediments. Sediment analysis is an important aspect of environmental quality and impact assessment for rivers, streams, and lakes. The Tennessee Department of Environment and Conservation's DOE Oversight Division (TDEC/DOE-O) conducts sediment monitoring for 23 sites. There are 10 sites on the Clinch River and 13 sites on tributaries of the Clinch. Clinch River Mile 52.6 (CRM 52.6) (site 2) is a background site and is located upstream of the Oak Ridge Reservation (ORR). Two of the tributary sites (24, 25) are located upstream of the ORR and serve as background sites. Sampling was conducted in 2005 during the months of April and May. Data are available online at EPA's STORET database (http://www.epa.gov/storet/).

Methods and Materials

Sediment samples were taken during April and May using the methods described in the 2005 Ambient Sediment Monitoring Plan. Samples were collected at locations with fine sediments; rocky or sandy areas were not used. River sediment samples were taken with a petite ponar dredge; stream samples were taken with stainless steel spoons. The Tennessee State Laboratories processed the samples, according to EPA approved methods.

Analytical Parameters

Inorganics: aluminum, arsenic, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, and zinc

Organics (extractables): 1,2,4,5-Tetrachlorobenzene, 1,2,4-Trichlorobenzene, 1-Amino-3-nitrobenzene, 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol (TCPh), 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2,4-Dinitrotoluene, 2,6-Dinitrotoluene, 2-Chloronaphthalene, 2-Chlorophenol, 2-Methylnaphthalene, 2-Nitroaniline, 2-Nitrophenol, 3,3'-Dichlorobenzidine, 4-Bromophenyl phenyl ether, 4-Chloro-3-methylphenol, 4-Chloroaniline, 4-Nitroaniline, 4-Nitrophenol, Acenaphthene, Acenaphthylene, Acetophenone, Aldrin, alpha-BHC, alpha-Endosulfan, Anthracene, Benzaldehyde, Benzo[a]anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Benzoic acid, Benzyl alcohol, beta-BHC, beta-Endosulfan, Biphenyl, bis(2-chloroethoxy) methane, bis(2-chloroethyl) ether, bis(2-chloroisopropyl) ether, bis(2-ethylhexyl) phthalate (DEHP), bis(n-octyl) Phthalate, Butyl benzyl phthalate, Caprolactam, Carbazole, Chlordane, Chlorophenyl-4 phenyl ether, Chrysene, cis-Chlordane, DDD, DDE, DDT, delta-BHC, Dibenzo[a,h]anthracene, Dibenzofuran, Dibutyl phthalate, Dieldrin, Diethyl phthalate, Dimethyl phthalate, Dinitro-o-cresol, Endosulfan Sulfate, Endrin, Endrin Aldehyde, Endrin ketone, Fluoranthene, C1-C4, Fluorene, C1-C3, gamma-BHC (Lindane), gamma-Chlordane, Heptachlor, Heptachlor epoxide, Hexachlorobenzene, Hexachlorobutadiene, Hexachlorocyclopentadiene, Hexachloroethane, Indeno[1,2,3-cd]pyrene, Isophorone, Methoxychlor, Naphthalene, nitro-Benzene, n-Nitrosodimethylamine, n-Nitrosodiphenylamine, n-Nitrosodipropylamine, o-Cresol, Pcb-aroclor 1221, Pcb-aroclor 1232, Pcb-aroclor 1242, Pcb-aroclor 1248, Pcb-aroclor 1254, Pcb-aroclor 1260, Pcb-aroclor 1262, p-Cresol, Pentachlorophenol (PCP), Phenanthrene, C1-C4, Pyrene, Pyridine, and Toxaphene.

Radiological: gross alpha, gross beta, and gamma radionuclides.

Sampling Sites
Site 2 – Clinch River Mile 52.6: This site is upstream of any possible DOE impacts and is a reference site in this respect. It may, however, show effects of any agricultural, industrial and residential activities upstream. The coordinates are approximately 36º 03' 46" N latitude and -84º 11' 49" W longitude. See figure 1.4.

Site 3 - Melton Hill Park, CRM 35.5: This site is near a big public park on the Clinch River. The coordinates are approximately 35º 56' 39" N latitude and -84º 14' 21" W longitude. See figure 1.3.

Site 4 - Grubb Islands, CRM 17.9: The coordinates are approximately 35º 53' 52" N latitude and -84º 22' 24" W longitude. See figure 1.2.

Site 5 - Brashear Island, CRM 10.1: The coordinates are approximately 35º 55' 13" N latitude and -84º 26' 02" W longitude. See figure 1.1.

Site 6 - Clinch River Mile 48.7: The coordinates are approximately 36º 01' 28" N latitude and -84º 10' 02" W longitude. See figure 1.4.

Site 7 - Clinch River Mile 41.2: The coordinates are approximately 35º 58' 30" N latitude and -84º 12' 30" W longitude. See figure 1.3.

Site 8 - Scarboro Creek: The coordinates are approximately 35º 58' 59" N latitude and -84º 13' 00" W longitude. The mouth of this stream is at CRM 41.2 (figure 1.3).

Site 9 - Kerr Hollow Branch: The coordinates are approximately 35º 58' 45" N latitude and -84º 13' 37" W longitude. The mouth of this stream is at CRM 41.2 (figure 1.3).

Site 10 - McCoy Branch: The coordinates are approximately 35º 57' 57" N latitude and -84º 14' 54" W longitude. The mouth of this stream is at CRM 37.5 (figure 1.3).

Site 12 - East Fork of Walker Branch: The coordinates are approximately 35º 57' 22" N latitude and -84º 15' 58" W longitude. The mouth of this stream is at CRM 33.2 (figure 1.3).

Site 13 - Bearden Creek: The coordinates are approximately 35º 56' 05" N latitude and -84º 17' 01" W longitude. The mouth of this stream is at CRM 31.8 (figure 1.3).

Site 17 – Unnamed Stream: The coordinates are approximately 35º 54' 14" N latitude and -84º 20' 12" W longitude. The mouth of this stream is at CRM 20.0 (figure 1.2).

Site 18 - Raccoon Creek: The coordinates are approximately 35º 54' 12" N latitude and -84º 21' 05" W longitude. The mouth of this stream is at CRM 19.5 (figure 1.2).

Site 20 - Grassy Creek: The coordinates are approximately 35º 54' 36" N latitude and -84º 22' 55" W longitude. The mouth of this stream is at CRM 14.55 (figure 1.2).

Site 22 – Unnamed Stream: The coordinates are approximately 35º 54' 29" N latitude and -84º 23' 25" W longitude. The mouth of this stream is at CRM 14.45 (figure 1.2).

Site 23 – Ernie's Creek: The approximate coordinates are 36º 02' 19" N latitude and -84º 12' 47" W longitude. The mouth of this stream is at CRM 51.1 (figure 1.4).

Site 24 – White Creek: This stream is located in the Chuck Swann Wildlife Management Area in Union County. The approximate coordinates are 36º 20' 47" N latitude and -83º 53' 42" W longitude. The mouth of this stream is at CRM 102.4 (figure 1.6).

Site 25 – Clear Creek: The approximate coordinates are 36º 12' 49" N latitude and -84º 03' 33" W longitude. This is a background site. The mouth of this stream is at CRM 77.7 (figure 1.5).

Site 27 – Clinch River Mile 7.0: The coordinates are approximately 35º 53' 37" N latitude and -84º 27' 46" W longitude. See figure 1.1.

Site 28 – Clinch River Mile 4.0: The coordinates are approximately 35º 53' 29" N latitude and -84º 29' 55" W longitude. See figure 1.1.

Site 29 – Clinch River Mile 0.0: The coordinates are approximately 35º 51' 52" N latitude and -84º 32' 01" W longitude. See figure 1.1.

Site 32 – Jones Island (CRM 19.7): The coordinates are approximately 35º 54' 03" N latitude and -84º 21' 02" W longitude. See figure 1.2.

Site 33 – Poplar Creek Mile 1.0: The coordinates are approximately 36º 01' 03" N latitude and -84º 14' 21" W longitude. The mouth of this stream is at CRM 12.0 (figure 1.1).

Results and Discussion

Inorganics Analyses

Sediment mercury levels in the Clinch River downstream of the mouth of Poplar Creek are elevated. Mercury at these sites is higher than the background soil level (U.S. DOE 1993b: the estimate of the 95th percentile for ORR overall data on pages G-54 to G-56 was used as background). As seen on Charts 1.1 and 1.2 mercury is virtually undetectable at the sites upstream of the mouth of Poplar Creek.

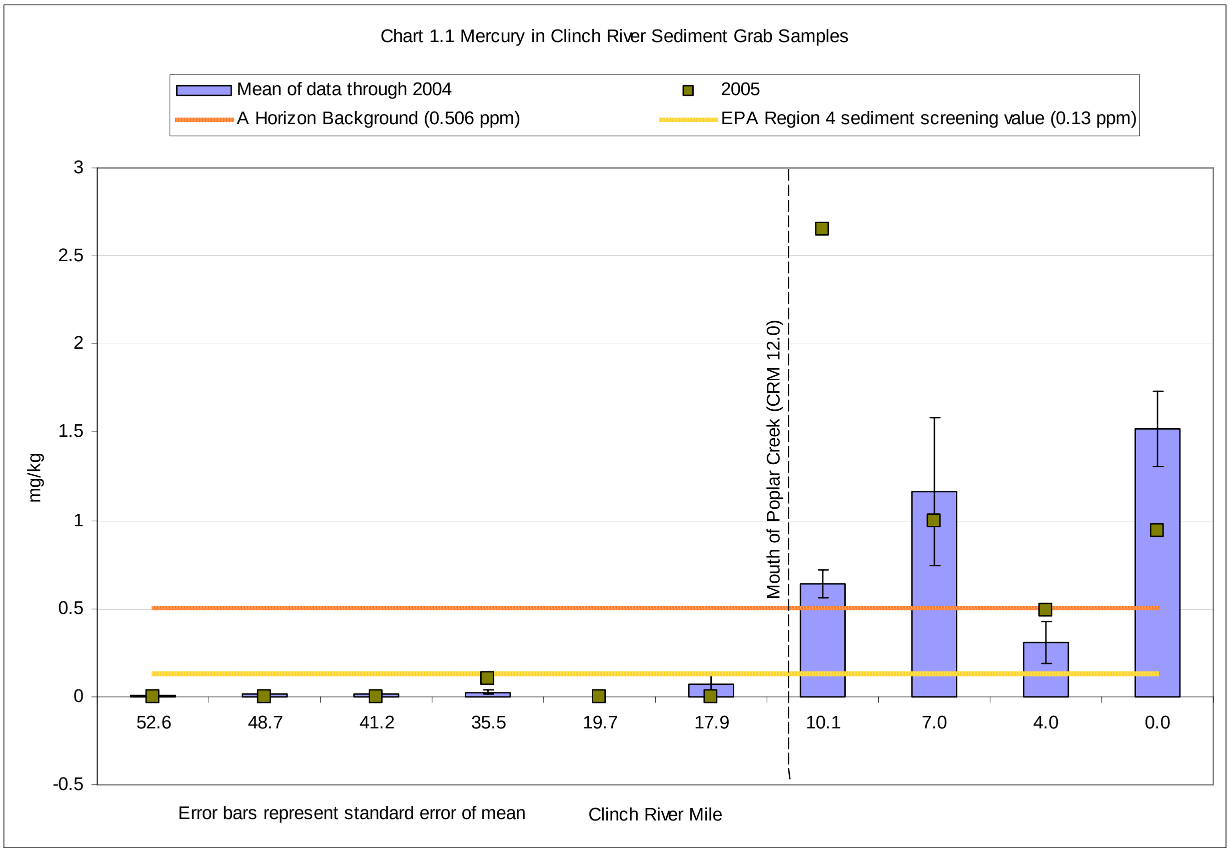


Chart 1.1 Mercury in Clinch River Sediment Grab Samples

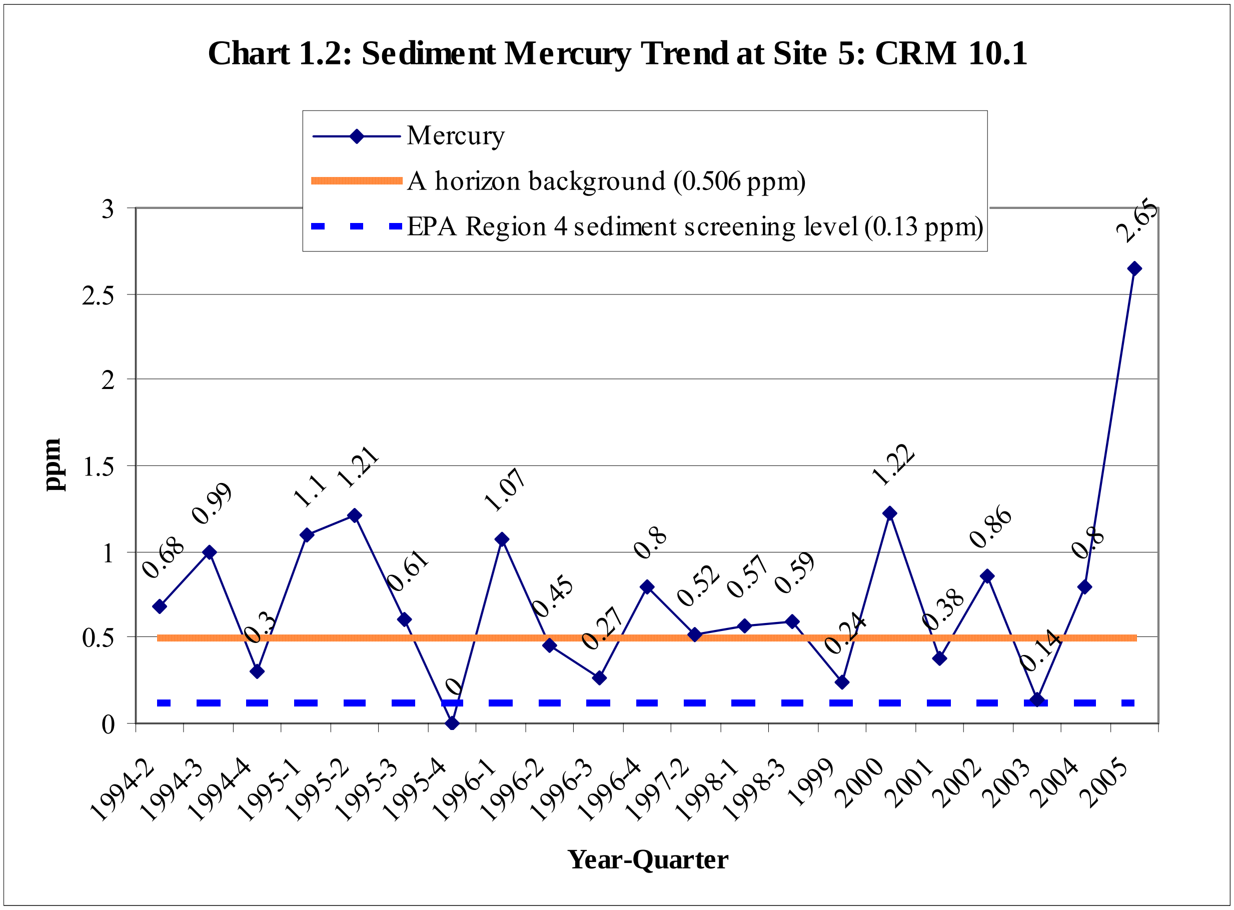


Chart 1.2: Sediment Mercury Trend at Site 5: CRM 10.1

At Poplar Creek Mile 1.0 (site 33), mercury is elevated (Chart 1.3). Site 22 (unnamed stream with mouth at CRM 14.45) also has slightly elevated sediment mercury levels; The mean of nine years of data is 0.565 ± 0.045 (mean ± standard error). This is above background for the Nolichucky-ORR soils. This slight elevation may be due to a concentration of suspended river sediments by the drinking water facility's filters and the backwashing of these sediments into a lagoon that has an outfall at the Clinch River. When the mercury numbers at site 22 are compared to the background level used for the River sites (ORR Overall: 0.506 mg/kg)(U.S. DOE 1993b) rather than the background level for the geological group it is in (Nolichucky-ORR), they do not appear to be elevated (U.S. DOE 1993a).

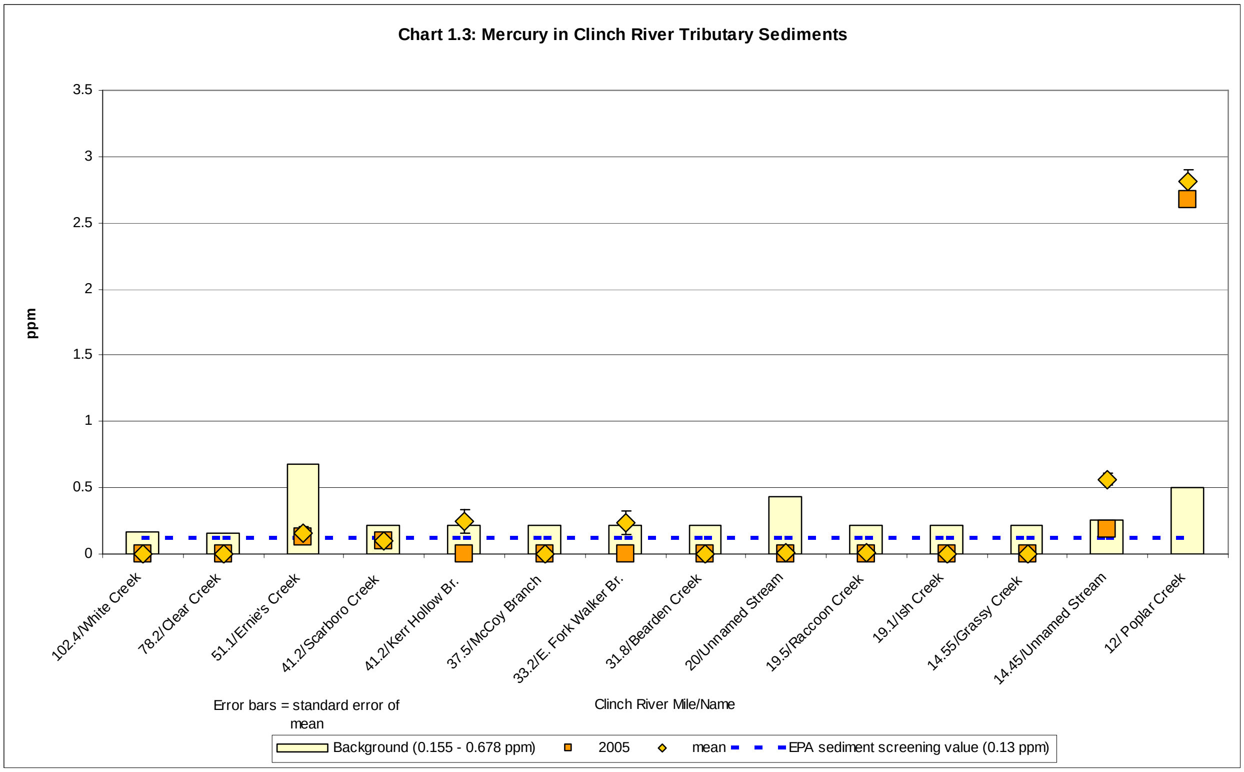


Chart 1.3: Mercury in Clinch River Tributary Sediments

None of the other inorganic parameters were found at levels significantly above background soil values or EPA Region 4 sediment screening values.

Organics Analyses

Polycyclic aromatic hydrocarbons (PAHs) are a group of chemicals that are created during the incomplete combustion of hydrocarbons, garbage, or other substances like tobacco or charbroiled meat. PAHs are usually found as a mixture of several of these compounds. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in the manufacture of medicines, dyes, plastics, and pesticides.

Two of the tributary sites show PAH contamination, Ernie's Creek (site 23) at CRM 51.1 and Scarboro Creek (site 8) at CRM 41.2. Ernie's Creek may have been contaminated by groundwater leakage of an old Oak Ridge landfill on the east side of town. Stormwater drainage from area roads may have also contributed with petroleum products spilled and leaked from vehicles. Scarboro Creek may have been contaminated by groundwater from an old landfill in Union Valley. Charts 1.4 and 1.5 show data for benzo(a)anthracene at these two sites. The data for the majority of the other high molecular weight (HMW) PAHs at these two streams is similar to charts 1.4 and 1.5 in that the means are greater than background soil data and EPA Region 4 sediment screening levels. The concentration of benzo(a)anthracene at this stream does not threaten human health; the Department of Energy (DOE) states that soils containing less than 6350 ppm (total soil PRG risk = 1e-6) do not pose a significant health risk to individuals using the area for recreational purposes (playing, fishing, hunting, hiking, or engaging in other outdoor activities) (U.S. DOE 2006). In 2005, there were several high values for PAHs at these two streams. The reason for these spikes is unknown at the present time; the situation will be investigated further in the months and years to come. Even these seemingly high spikes are within the expected background range for urban soils (ATSDR 1995, p. 262).

Chart 1.4: Sediment Benzo(a)anthracene at Site 8 (Scarboro Creek Mile 0.1)

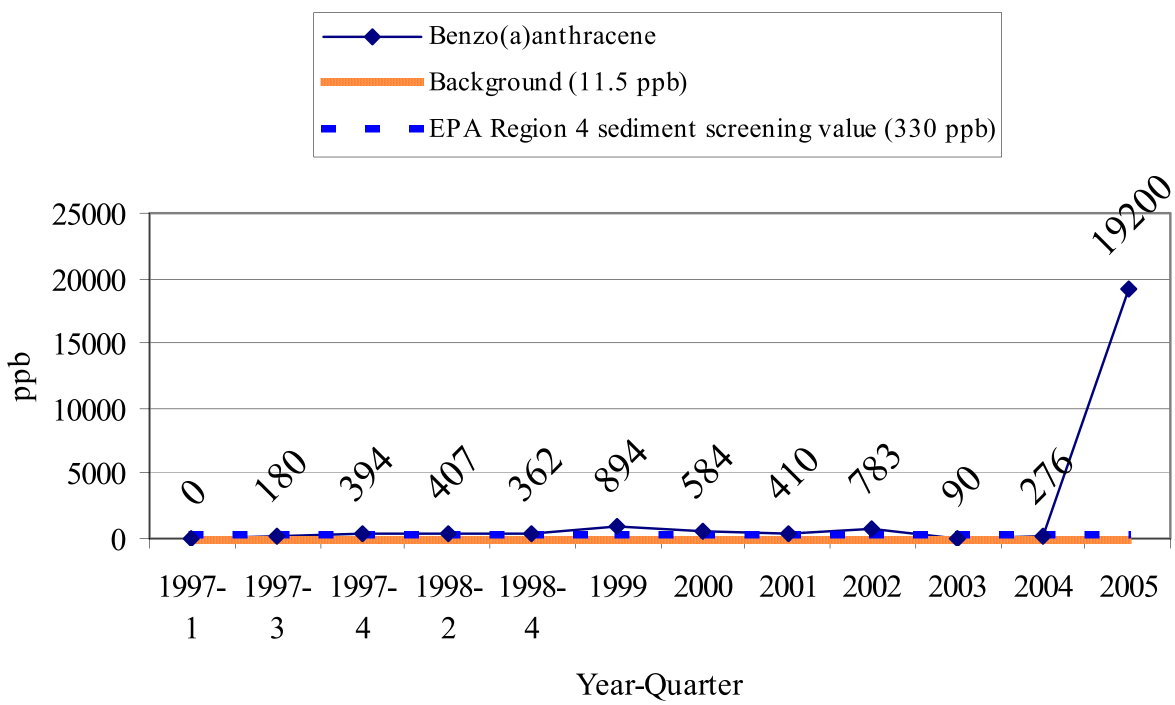
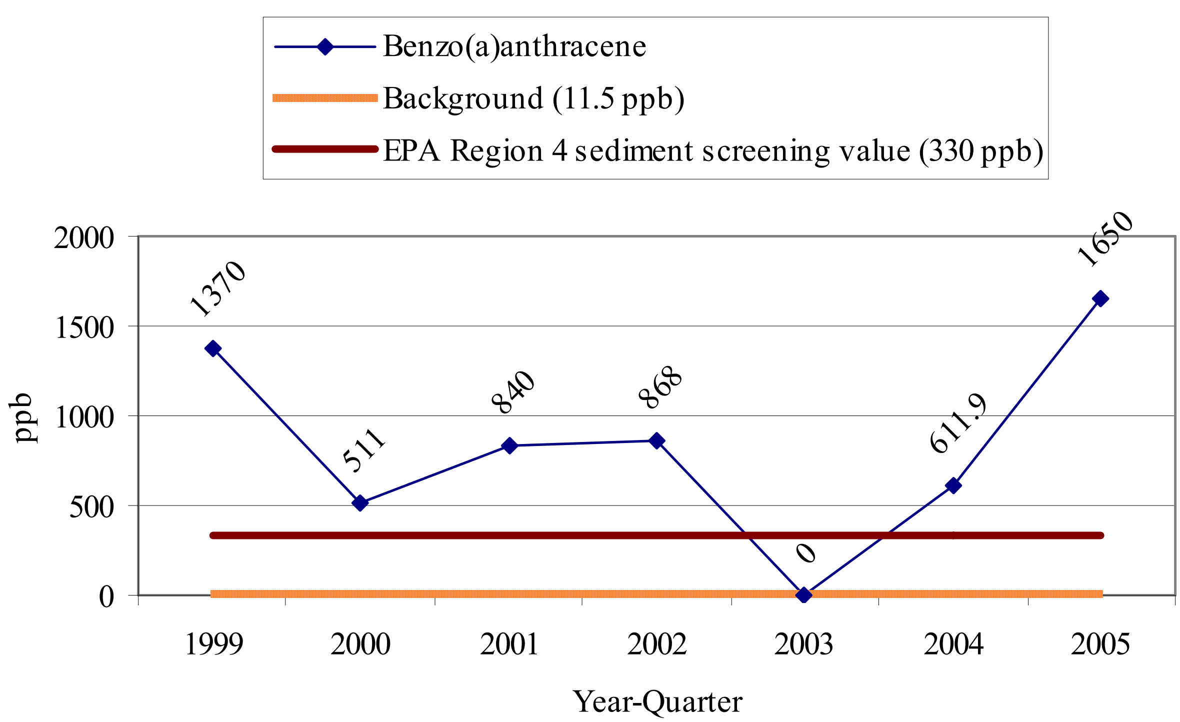


Chart 1.5: Sediment Benzo(a)anthracene at Site 23 (Ernie's Creek Mile 0.1)



Radiological Analyses

In the Clinch River, Cs137 levels are typically higher in samples taken downstream of the mouth of White Oak Creek than those taken upstream (see Chart 1.6). Site 22 (unnamed stream with mouth at CRM 14.45) has shown significantly higher levels of Cs137 than all of the other sites (see Chart 1.7). The mean for Cs137 at site 22 (based on 7 samples taken between 1997 and 2004) is 12.54 pCi/g (standard error = 3.29). This stream runs through the K-1515C lagoon that was once used to receive backwash material from filters at the ETTP Water Treatment Plant. One theory is that these filters concentrated the suspended Cs137-laden sediment from White Oak Creek, the mouth of which is approximately 6.3 miles upstream on the Clinch River. The K-1515C lagoon is no longer used for the purpose of disposing of filter backwash. The concentration of Cs137 at this stream does not threaten human health; the Department of Energy (DOE) states that soils containing less than 2580 pCi/g (total soil PRG risk = 1e-6) do not pose a significant health risk to individuals using the area for recreational purposes (playing, fishing, hunting, hiking, or engaging in other outdoor activities) (U.S. DOE 2006).

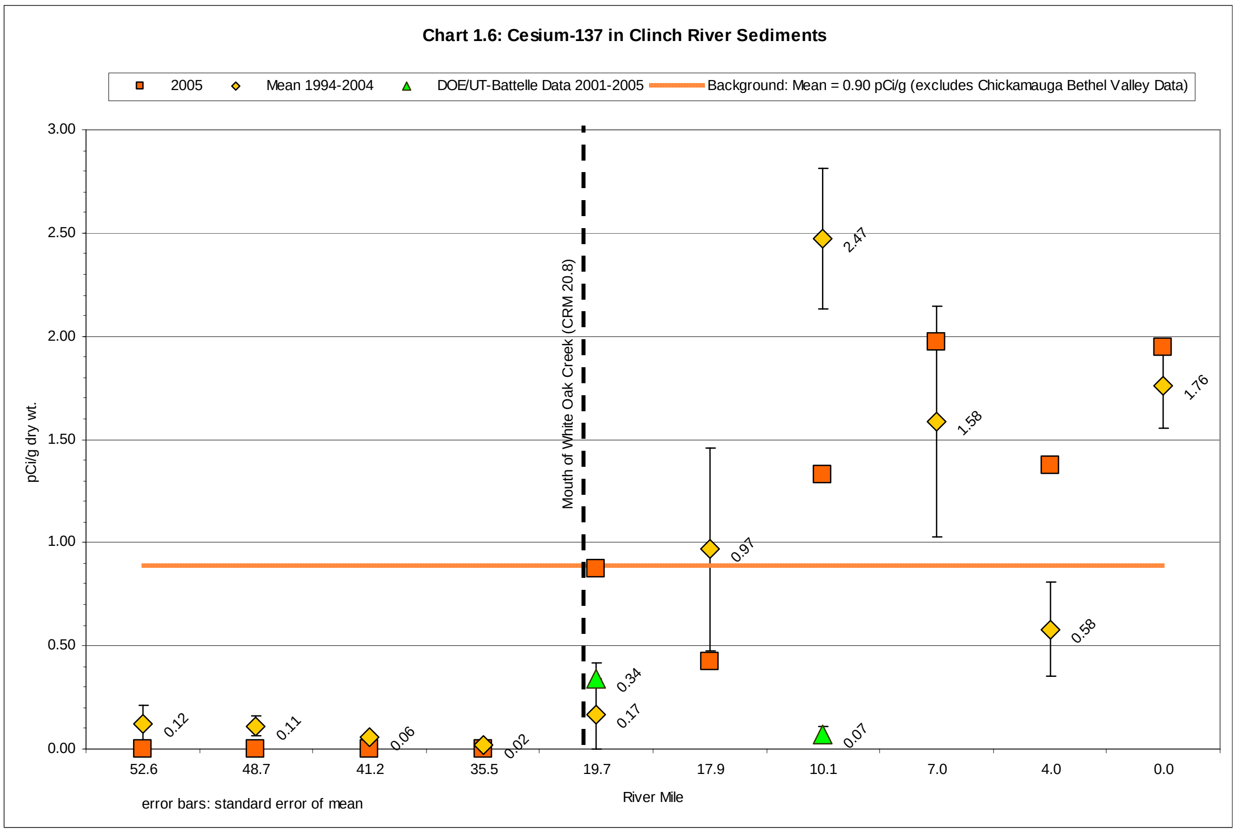


Chart 1.6: Cesium-137 in Clinch River Sediments

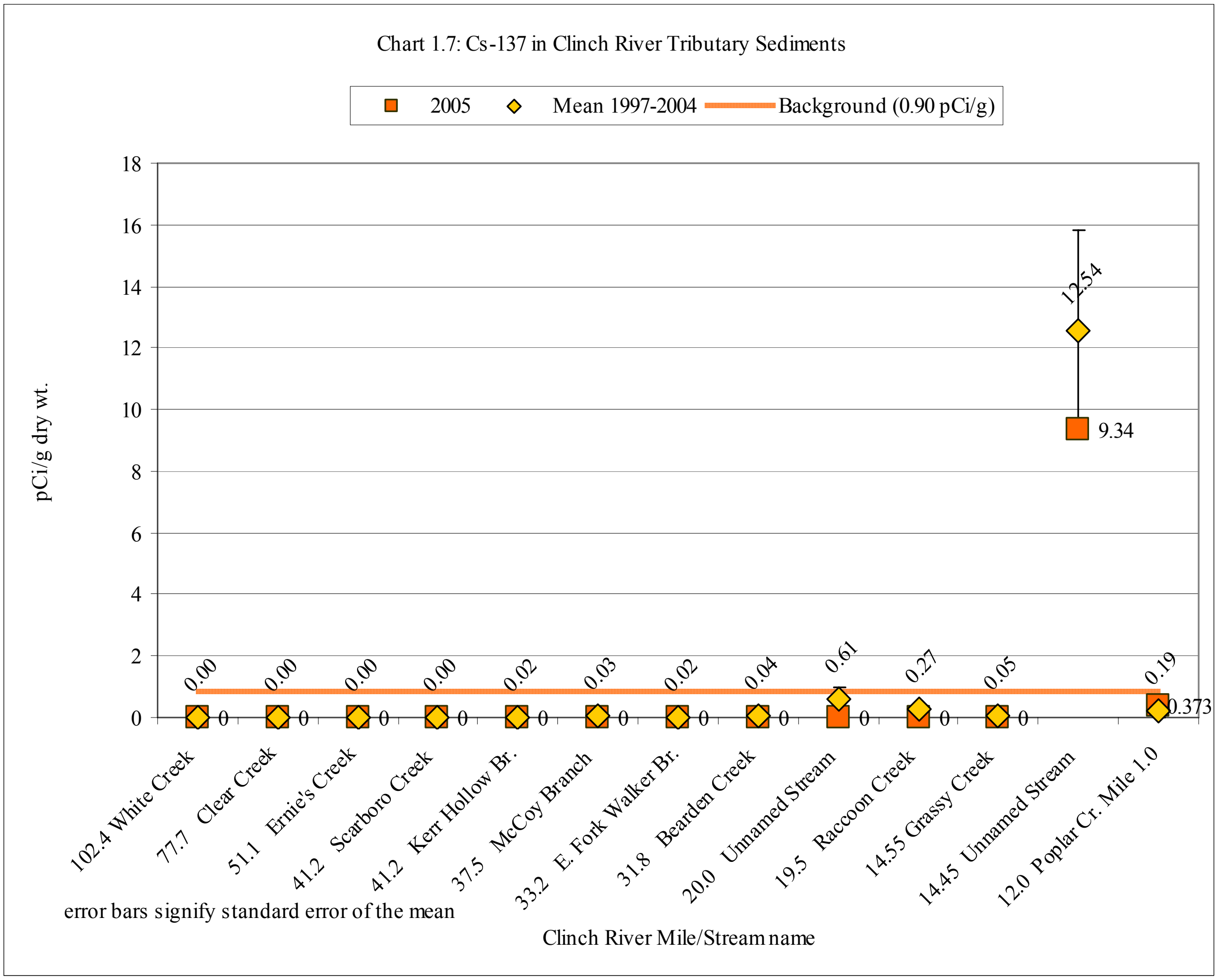


Chart 1.7: Cesium-137 in Clinch River Tributary Sediments

Sediment at site 5 (CRM 10.1) has Cs-137 levels above background as a result of contamination by White Oak Creek. Cs-137 is above background at most sites downstream of the mouth of White Oak Creek, but site 5 has the highest levels (Chart 1.6). Note the DOE sediment sampling data comparisons at CRM 19.7 (Jones Island) and at site 5 (Brashear's Island). The data at Jones Island is similar to TDEC DOE-O's data but the data for site 5 (CRM 10.1) is much lower than the TDEC data. This difference may be in the different sampling methods used: DOE/UT-Battelle takes sediment samples from the bank of the river whereas TDEC takes samples with a petite ponar dredge from the river channel. The DOE sampling method yields results that are more relevant to the typical recreational user; one is much more likely to be affected by the sediments on the shoreline than the sediments on the bottom of the river channel.

Conclusion

Sediment data from 2005 samplings show no levels of contamination that exceed DOE Preliminary Remediation Goals (PRGs) for recreation and based on these criteria do not pose a threat to human health. If in the future, these sediments are to be used for agricultural and/or other purposes, analysis may be performed to determine the suitability for these new purposes. Mercury levels in the samples taken in the Clinch River below the confluence of Poplar Creek increase as one goes downstream. Although the levels of mercury are well below the recreational PRG, they are higher than all of the other sediment sampling sites. Site 22 (CRM 14.45) has shown considerably higher levels of Cs-137 than all of the other sites. This is believed to be due to the effect of concentrating suspended Cs-137-contaminated sediment particles in river water by filters at the ETTP Water Treatment Plant and disposing of the filter backwash material in the K-1515C lagoon. This lagoon is no longer used for this purpose. Cs-137 is found at levels that are above background at most of the sites below the mouth of White Oak Creek. The levels are very low and do not pose a threat to human health. This contamination appears to be decreasing over time as a result of the radioactive decay of the Cs-137.

Figure 1.1: Sediment Monitoring Sites

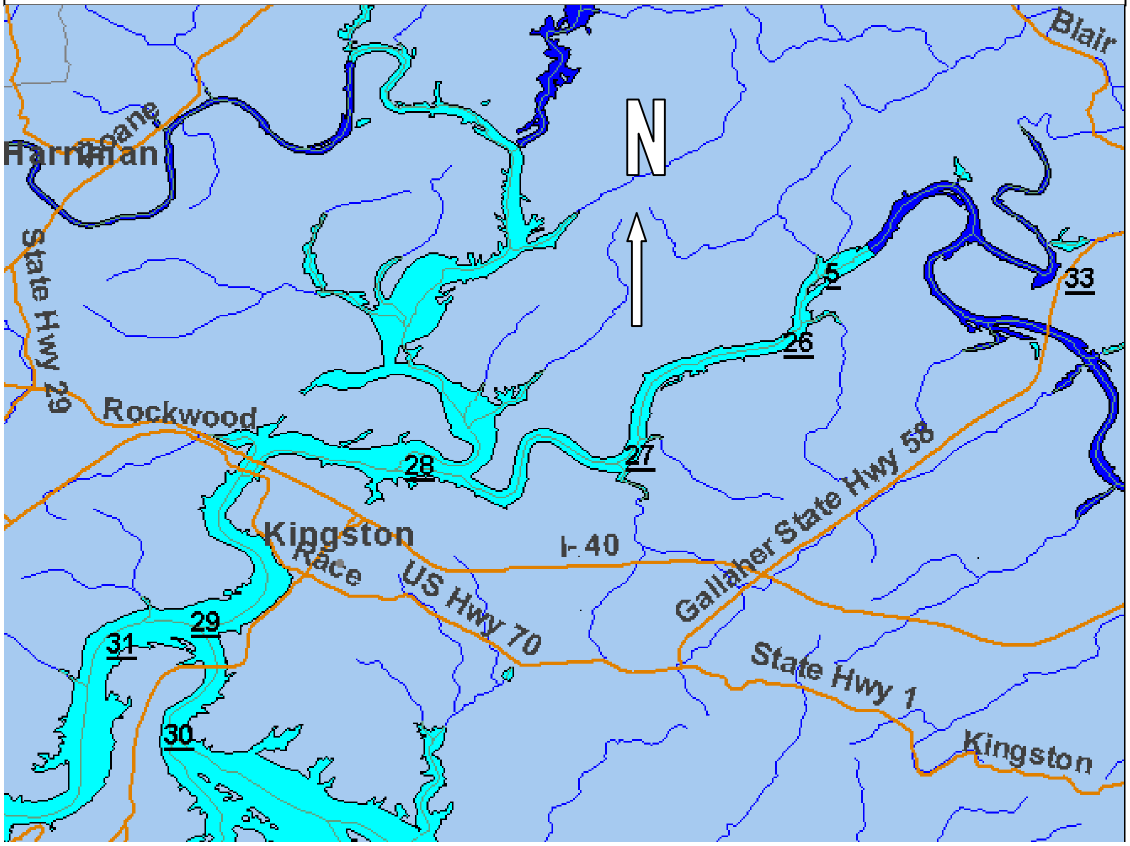


Figure1.2: Sediment Monitoring Sites

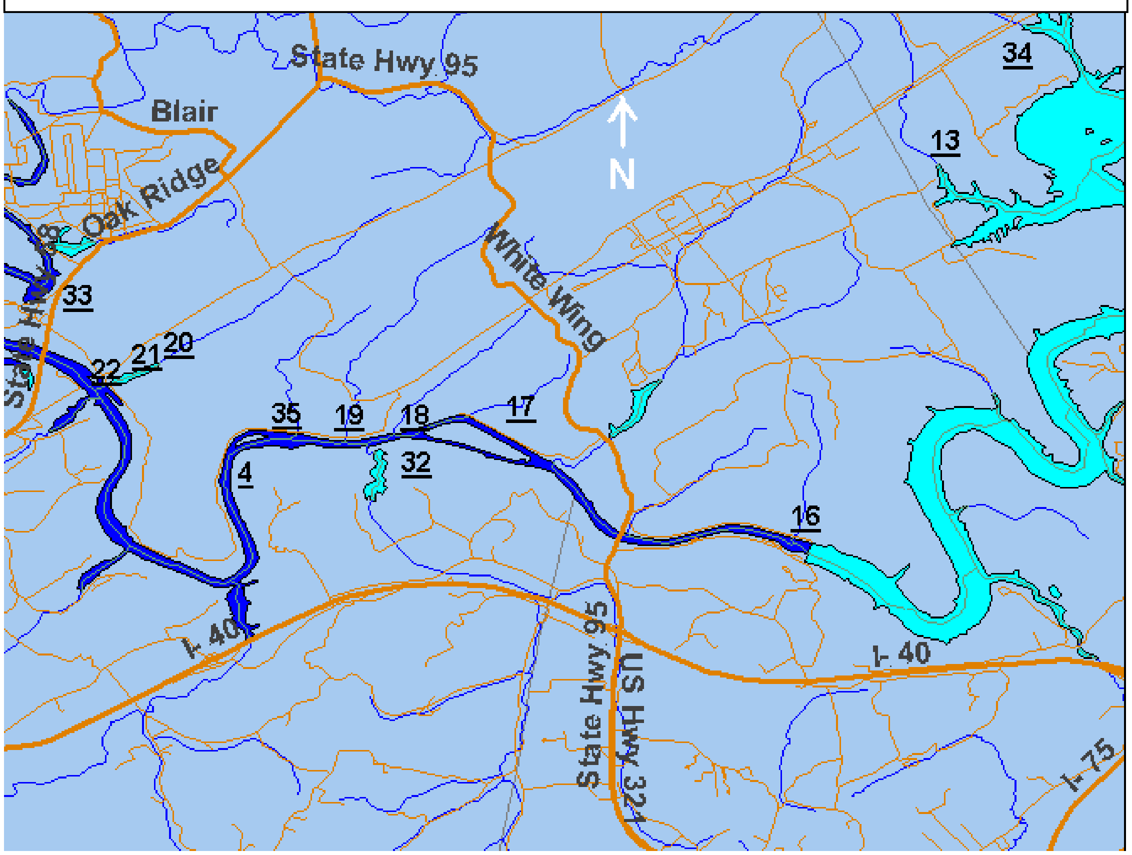


Figure 1.3: Sediment Monitoring Sites

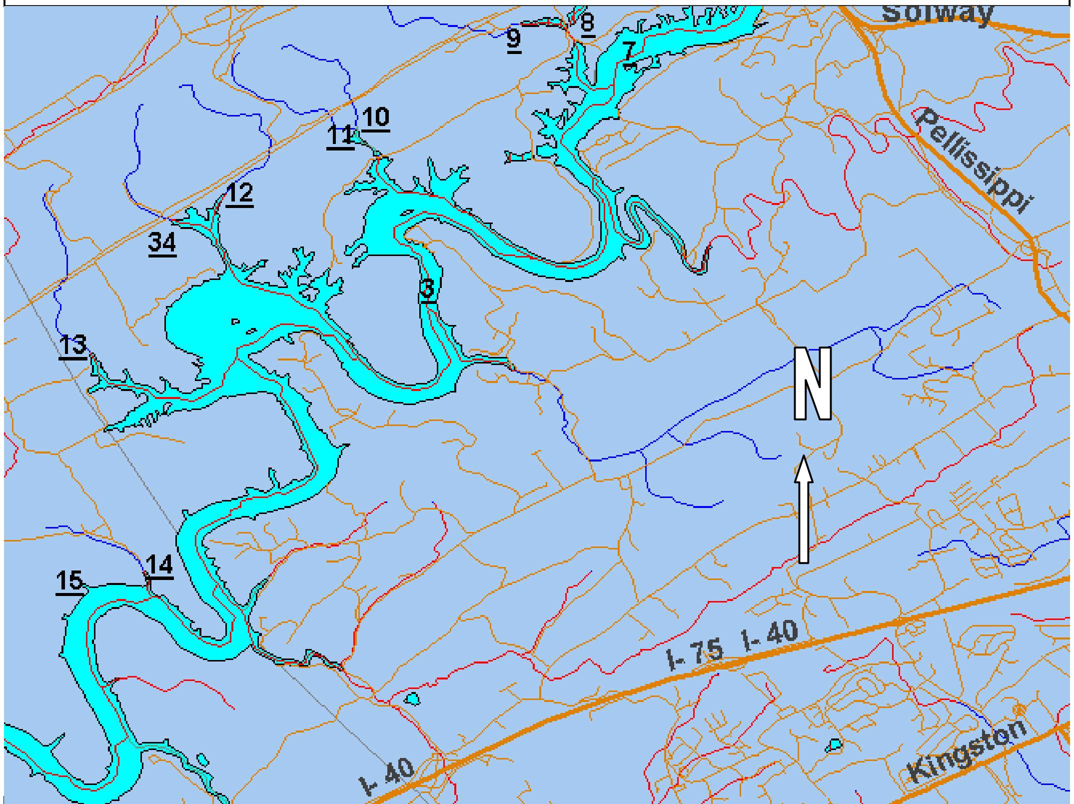


Figure 1.4: Sediment Monitoring Sites

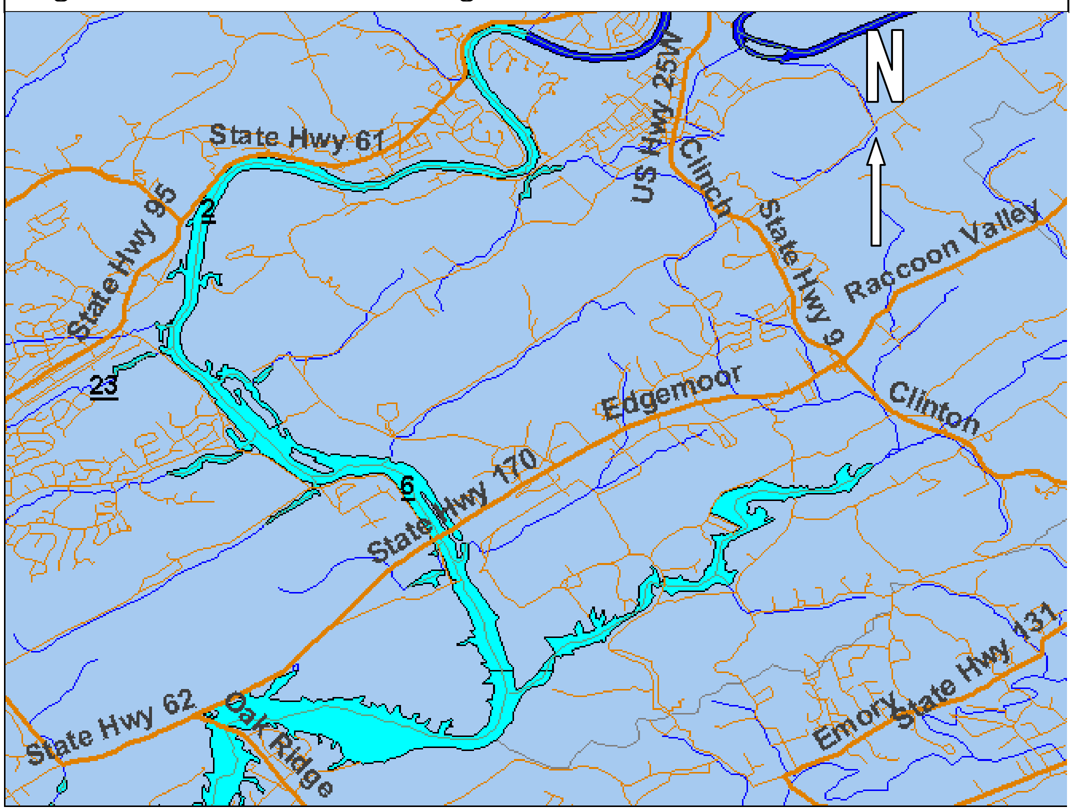


Figure 1.5: Sediment Monitoring Sites

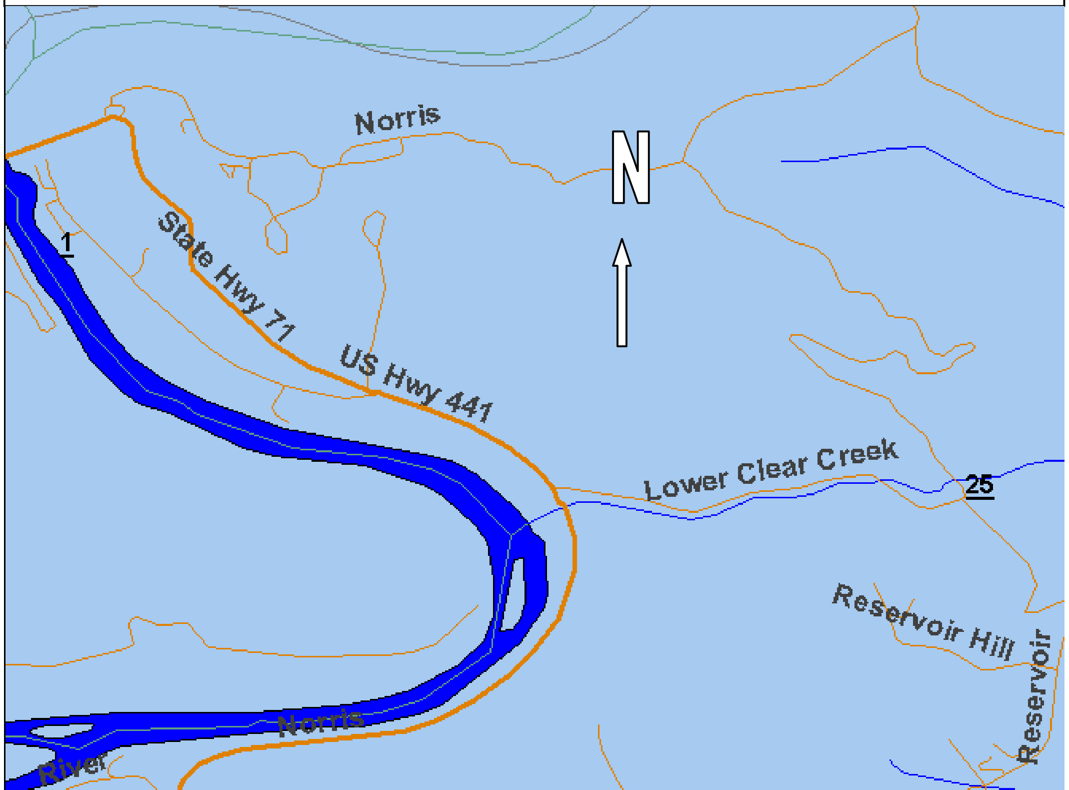
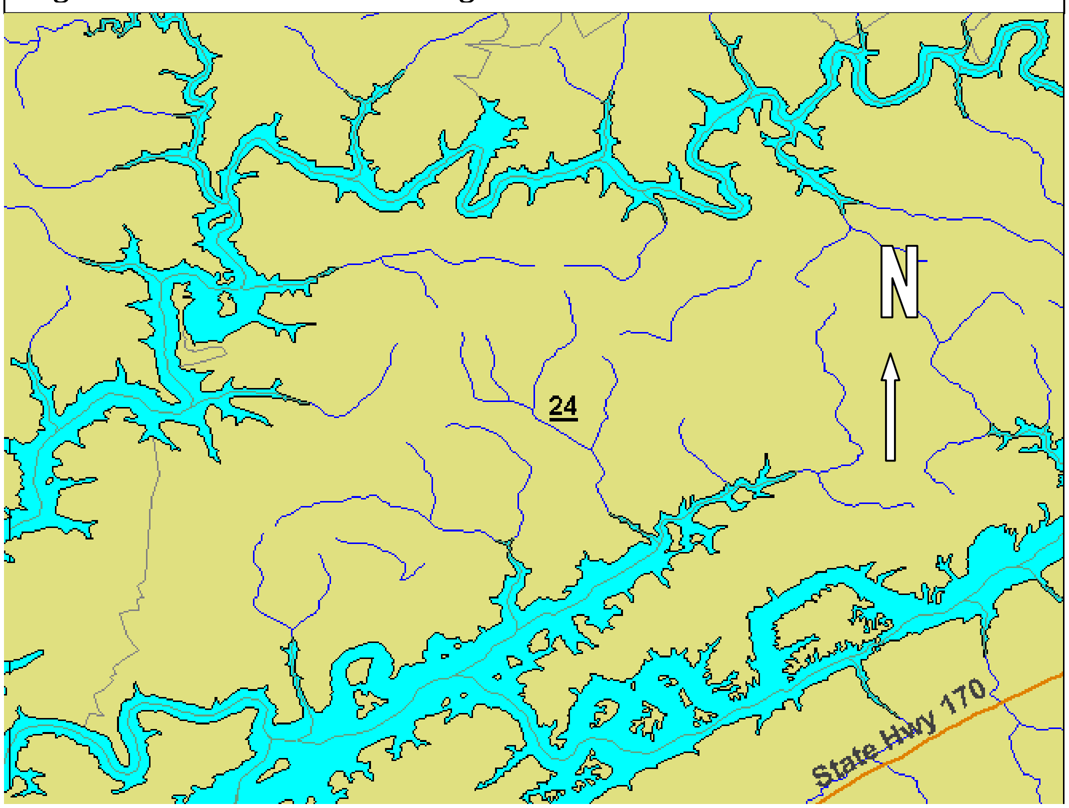


Figure 1.6: Sediment Monitoring Sites



References

ASTM (American Society for Testing and Materials) 1990. *Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing*. E 1391-90. Philadelphia, Pennsylvania.

ATSDR (Agency for Toxic Substances and Disease Registry) 1995. *Toxicological Profile for Polycyclic Aromatic Hydrocarbons.* Atlanta, Georgia.

Region IV (U.S. Environmental Protection Agency) 1991. *Environmental Compliance Standard Operating Procedures and Quality Assurance Manual*. Environmental Services Division, U.S. Environmental Protection Agency Region IV, Atlanta, Georgia.

TDEC DOE-O (Tennessee Department of Environment and Conservation, Department of Energy Oversight) 1996. *Standard Operating Procedures*. Oak Ridge, Tennessee.

TDH (Tennessee Department of Health Laboratory Services) 1999. *Standard Operating Procedures.* Nashville, Tennessee.

Thomasson, D. A. 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

U.S. DOE (Department of Energy) 1993a. *Final Report on the Background Soil Characterization Project at the Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1175/V1, Oak Ridge, Tennessee.

U.S. DOE (Department of Energy) 1993b. *Final Report on the Background Soil Characterization Project at the Oak Ridge Reservation, Oak Ridge, Tennessee,* DOE/OR/01-1175/V2, Oak Ridge, Tennessee.

U.S. DOE (Department of Energy), Oak Ridge Operations Office (ORO) 2006. *Risk Assessment Information System (RAIS).* Retrieved February 1, 2006, from the RAIS web site: http://risk.lsd.ornl.gov/cgi-bin/prg/PRG_search

CHAPTER 6 SURFACE WATER MONITORING

ORR Surface Water Monitoring (Physical Parameters)

Principal Author: Gerry Middleton

Abstract

Due to the presence of areas of extensive point and non-point source contamination on the Oak Ridge Reservation (ORR), there exists the potential for this pollution to impact surface waters on the ORR as well as offsite aquatic systems. The local karst topography and related structural geology influences the fate and transport of contaminants that may further degrade the groundwater and surface water quality of aquatic systems adjacent to the ORR. Therefore, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division), collected ambient water quality data at seven ORR and offsite stream locations during 2005. The field data results, collected twice a month, are summarized in Figure 2.

Introduction

The Division began to collect ambient, real time water quality monitoring data at seven stream sites dispersed in several watersheds during 2005 (Map 1). The main watersheds include East Fork Poplar Creek, Bear Creek, and Mitchell Branch. Field data were also collected from Mill Branch, a small reference stream located in the city of Oak Ridge. The EFK 13.8 km monitoring location is offsite of the ORR, yet is approximately 10 km downstream from sources of anthropogenic pollution associated with the Y-12 National Security Complex. The project objectives were to create a baseline of water quality monitoring data (physical stream parameters) gathered on a regular basis (every two weeks), and to determine possible water quality impairment issues. Furthermore, this monitoring task was directed toward determining long-term water quality trends, assessing attainment of water quality standards and providing background data for evaluating stream recovery due to toxicity stressors. Figure 1 is a list of the field monitoring sites that were selected for data collection during 2005.

Figure 1. Sample Locations

Site	Location
EFK 23.4	Station 17
EFK 13.8	Oak Ridge Sewage Treatment Plant
BCK 4.5	Bear Creek Weir at Hwy. 95
BCK 9.6	Bear Creek Monitoring Location
BCK 12.3	Bear Creek Monitoring Location
MIK 0.1	Mitchell Branch Weir
MBK 1.6	Mill Branch (Reference)

Methods and Materials

Parameters collected were temperature, pH, conductivity, dissolved oxygen, and turbidity. The Horiba® U-10 Water Quality Checker instrument is a simultaneous, multi-parameter instrument used for measuring water quality including all these parameters. The instrument consists of a probe unit (with various sensors) attached to a handheld unit (LCD readout & keypad) via a 3-foot cable. Measurements were taken simply by immersing the probe directly into the creek, pond, or river, and parameter readings were recorded from the hand-held unit LCD readout (one parameter at a time is displayed and is initialized using the keypad). The instrument was pre-calibrated prior to each field departure, and the information recorded in a division laboratory logbook. During each stream examination, the Horiba data was recorded in a field notebook including time, date and weather conditions. One team member recorded the instrument readings and other field notes, while the other person operated the Horiba instrument. Unusual occurrences relating to stream conditions were duly noted.

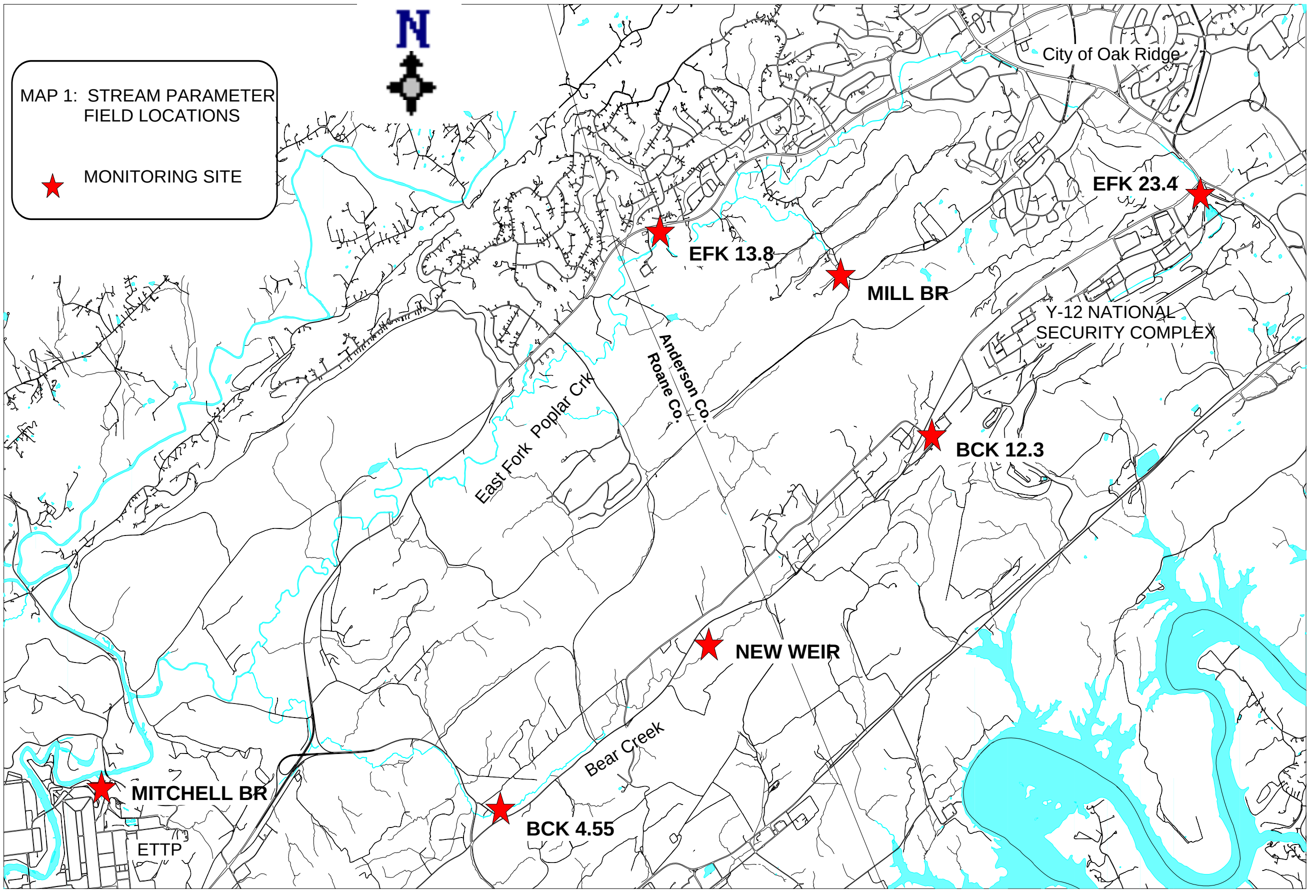
In case field readings such as pH and conductivity were beyond benchmark ranges, then the following action was taken: (1) wait 24 hours, re-calibrate the Horiba, and collect new physical parameter readings; (2) if readings are still deviant, investigate possible causes (e.g., defective equipment, storm surge/rain events, releases that may have affected pH, etc.); (3) following investigation, report findings to appropriate program(s) within the division to determine further action, if needed. Field and monitoring methods, and health and safety procedures were followed per the Tennessee Department of Health's *Standard Operating Procedures* (TDH 1999), and the TDEC DOE-O *Health, Safety, and Security Plan* (Thomasson 2005).

Results and Discussion

Thirty-two sets of field data were collected from the monitoring sites in 2005. Most of the data collected are within normal ranges for surface waters monitored in the ORR vicinity. The mean data are presented in Charts 1-7 on a logarithmic scale. Conductivity numbers (only) are shown at the top of the x-axis for ease of interpretation. There were no April data collected.

Conclusion

The data met all State water quality criteria for the parameters observed at the seven monitoring stations. However, consistently high conductivity readings observed at Bear Creek km 12.3 (BCK 12.3) suggests degraded water quality due to high nutrients in the aquatic system. BCK 12.3 is located downstream and west of the capped S-3 Ponds site and the Y-12 West End water treatment facility.


MAP 1: STREAM PARAMETER FIELD LOCATIONS
MONITORING SITE
N
City of Oak Ridge
EFK 23.4
EFK 13.8
MILL BR
Y-12 NATIONAL SECURITY COMPLEX
Anderson Co.
Roane Co.
East Fork Poplar Crk
BCK 12.3
NEW WEIR
Bear Creek
MITCHELL BR
BCK 4.55
ETTP

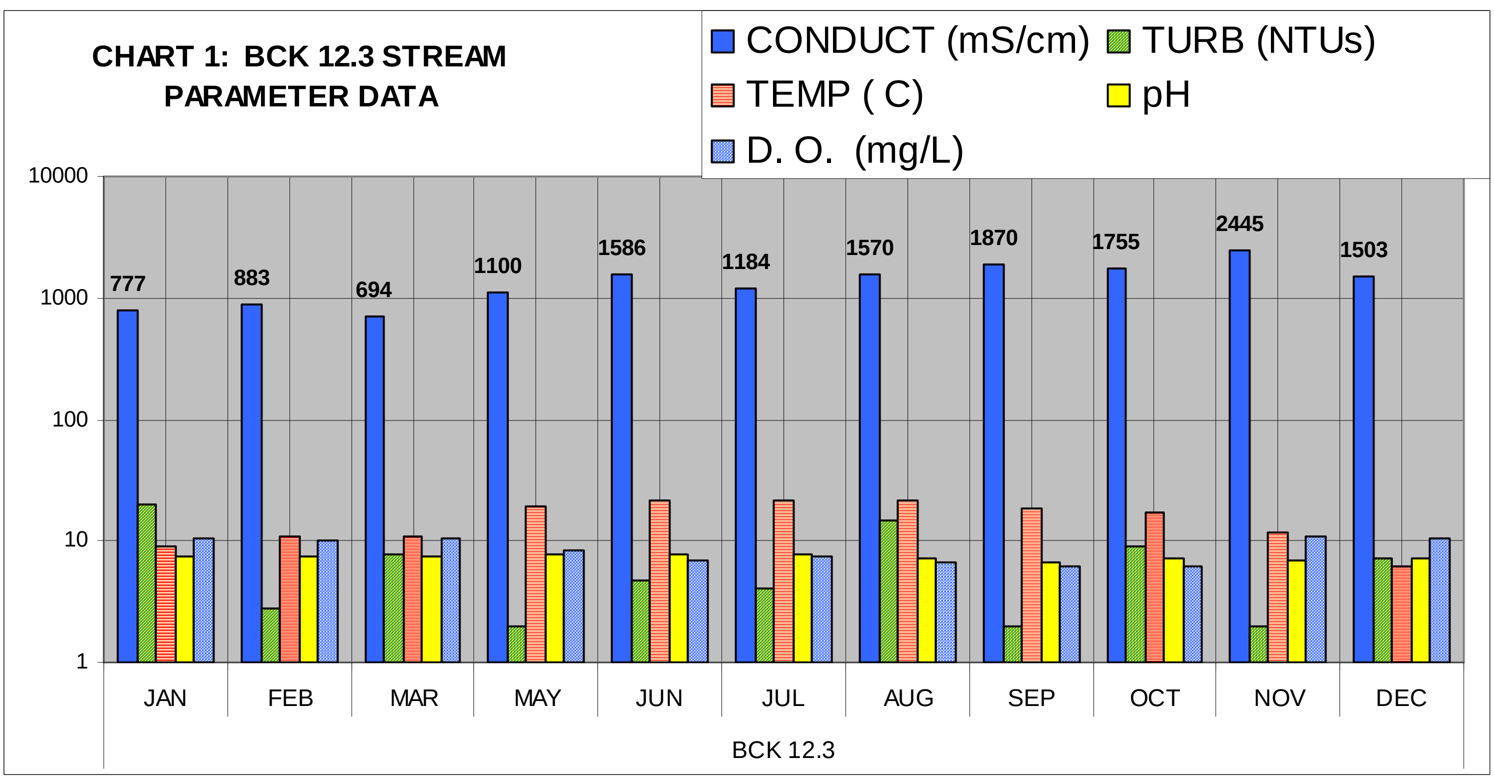


CHART 1: BCK 12.3 STREAM PARAMETER DATA
CONDUCT (mS/cm)
TURB (NTUs)
TEMP (C)
pH
D. O. (mg/L)
10000
1000
100
10
1
777
883
694
1100
1586
1184
1570
1870
1755
2445
1503
JAN
FEB
MAR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
BCK 12.3

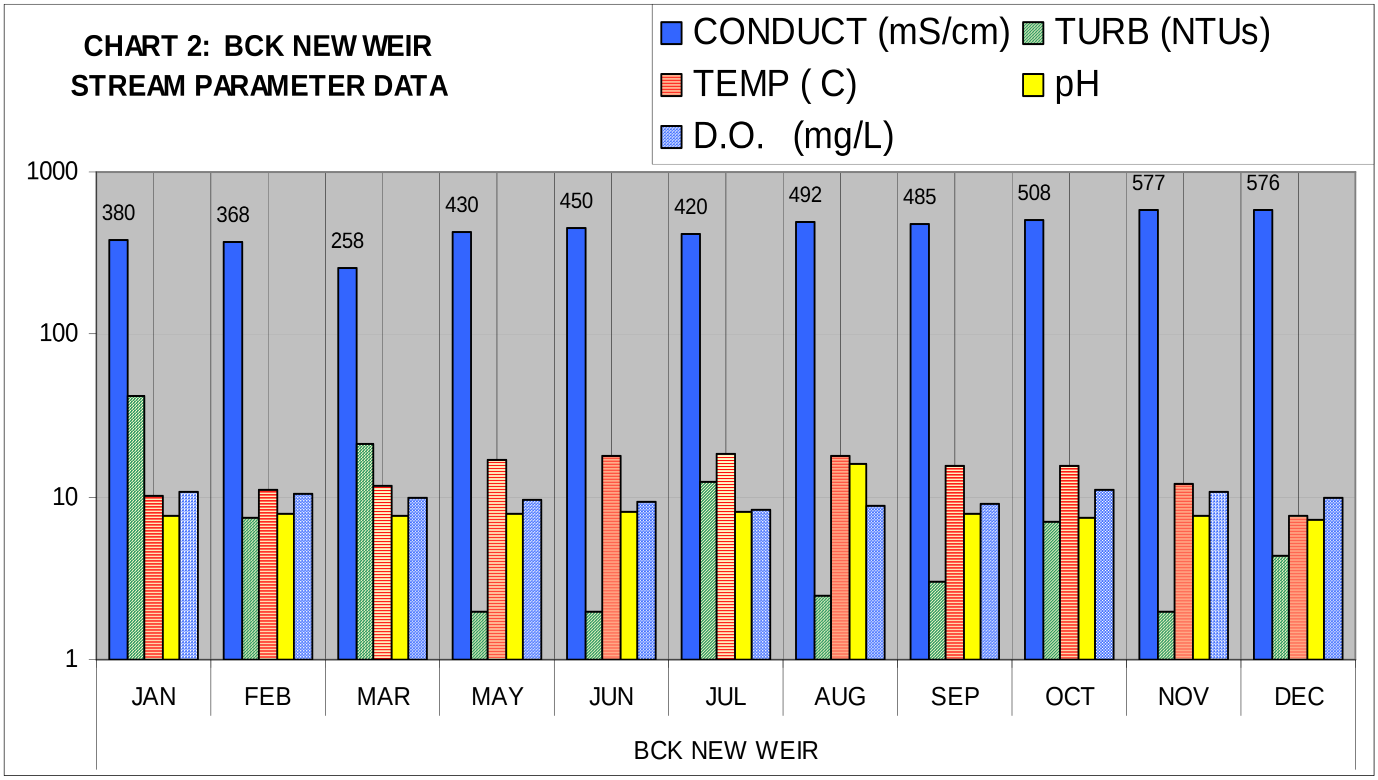


CHART 2: BCK NEW WEIR
STREAM PARAMETER DATA
CONDUCT (mS/cm)
TURB (NTUs)
TEMP (C)
pH
D.O. (mg/L)
1000
100
10
1
380
368
258
430
450
420
492
485
508
577
576
JAN
FEB
MAR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
BCK NEW WEIR

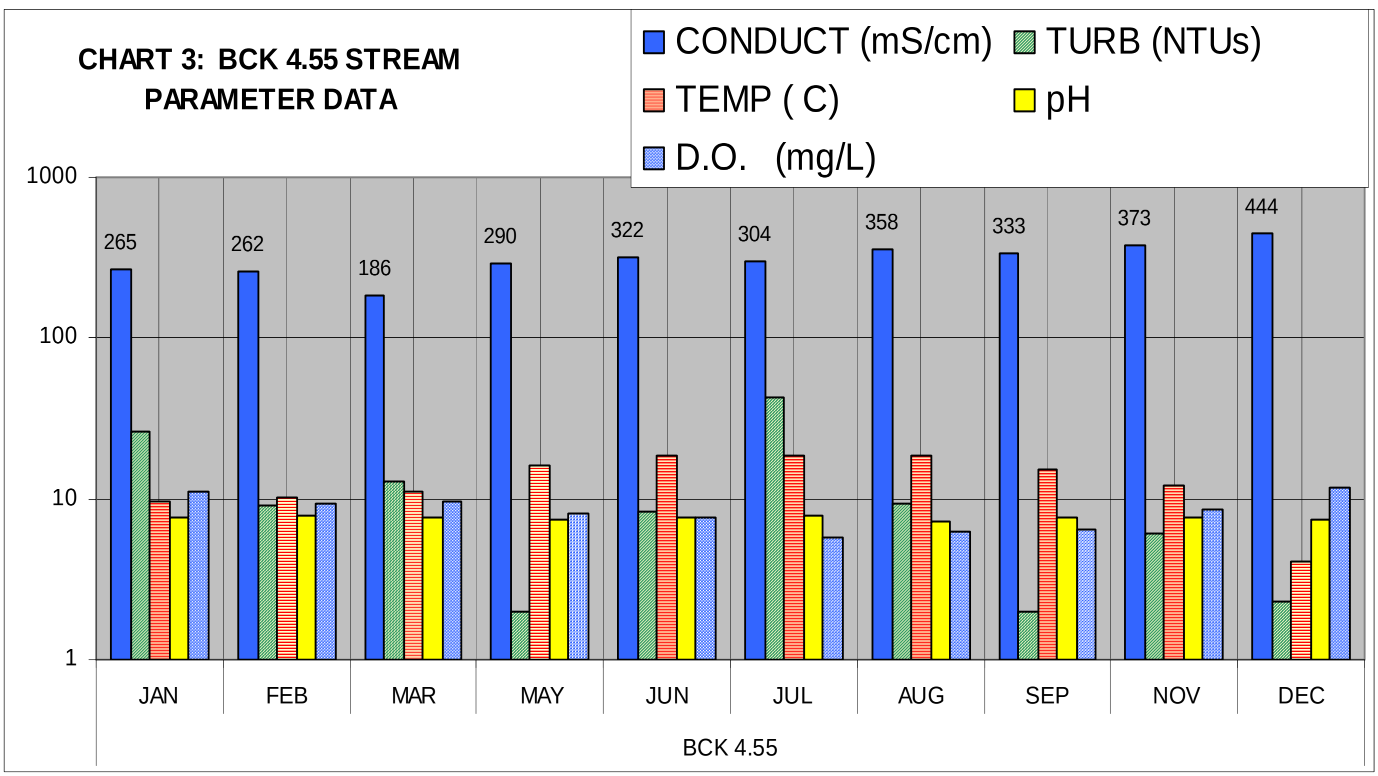


CHART 3: BCK 4.55 STREAM
PARAMETER DATA
CONDUCT (mS/cm)
TURB (NTUs)
TEMP (C)
pH
D.O. (mg/L)
1000
100
10
1
265
262
186
290
322
304
358
333
373
444
JAN
FEB
MAR
MAY
JUN
JUL
AUG
SEP
NOV
DEC
BCK 4.55

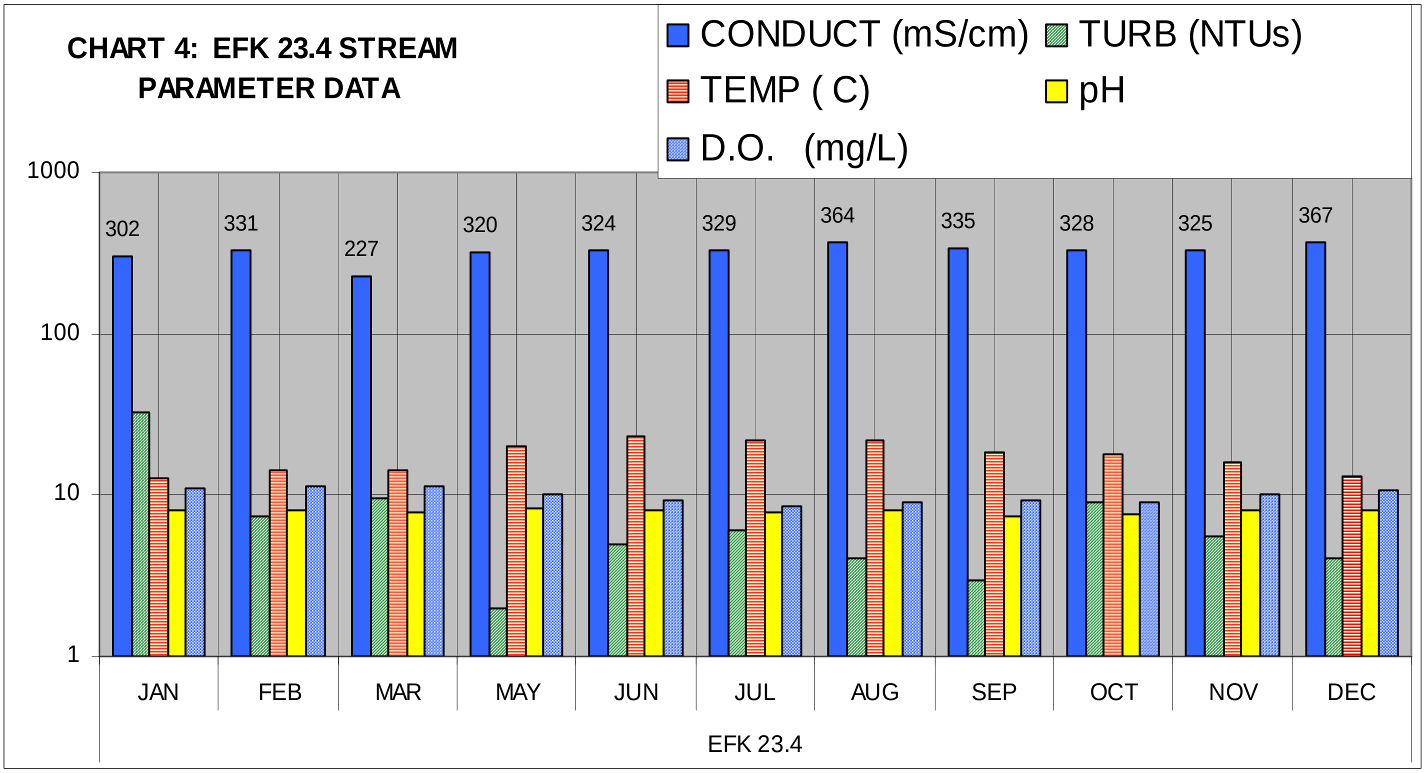


CHART 4: EFK 23.4 STREAM PARAMETER DATA
CONDUCT (mS/cm)
TURB (NTUs)
TEMP (C)
pH
D.O. (mg/L)
1000
100
10
1
302
331
227
320
324
329
364
335
328
325
367
JAN
FEB
MAR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
EFK 23.4

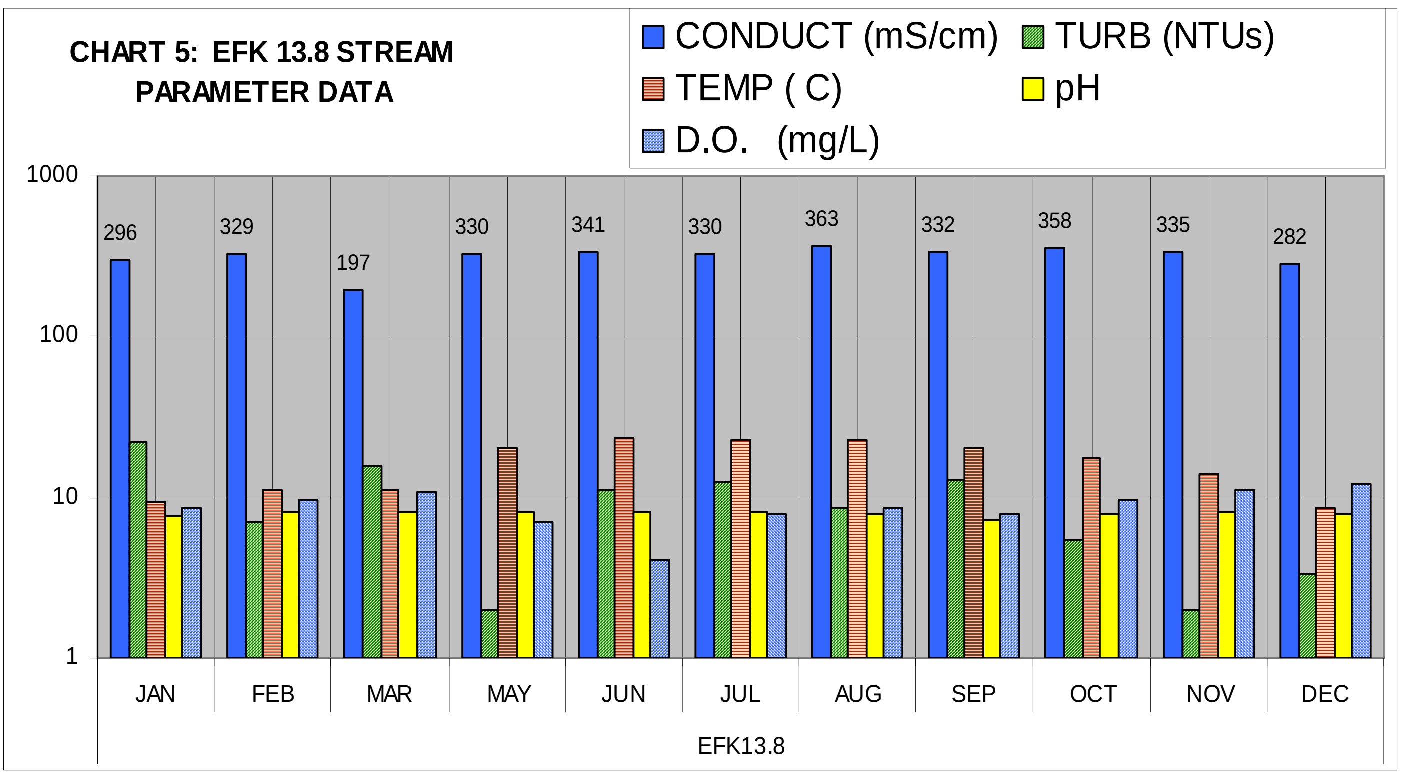


CHART 5: EFK 13.8 STREAM PARAMETER DATA
CONDUCT (mS/cm)
TURB (NTUs)
TEMP (C)
pH
D.O. (mg/L)
1000
100
10
1
296
329
197
330
341
330
363
332
358
335
282
JAN
FEB
MAR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
EFK13.8

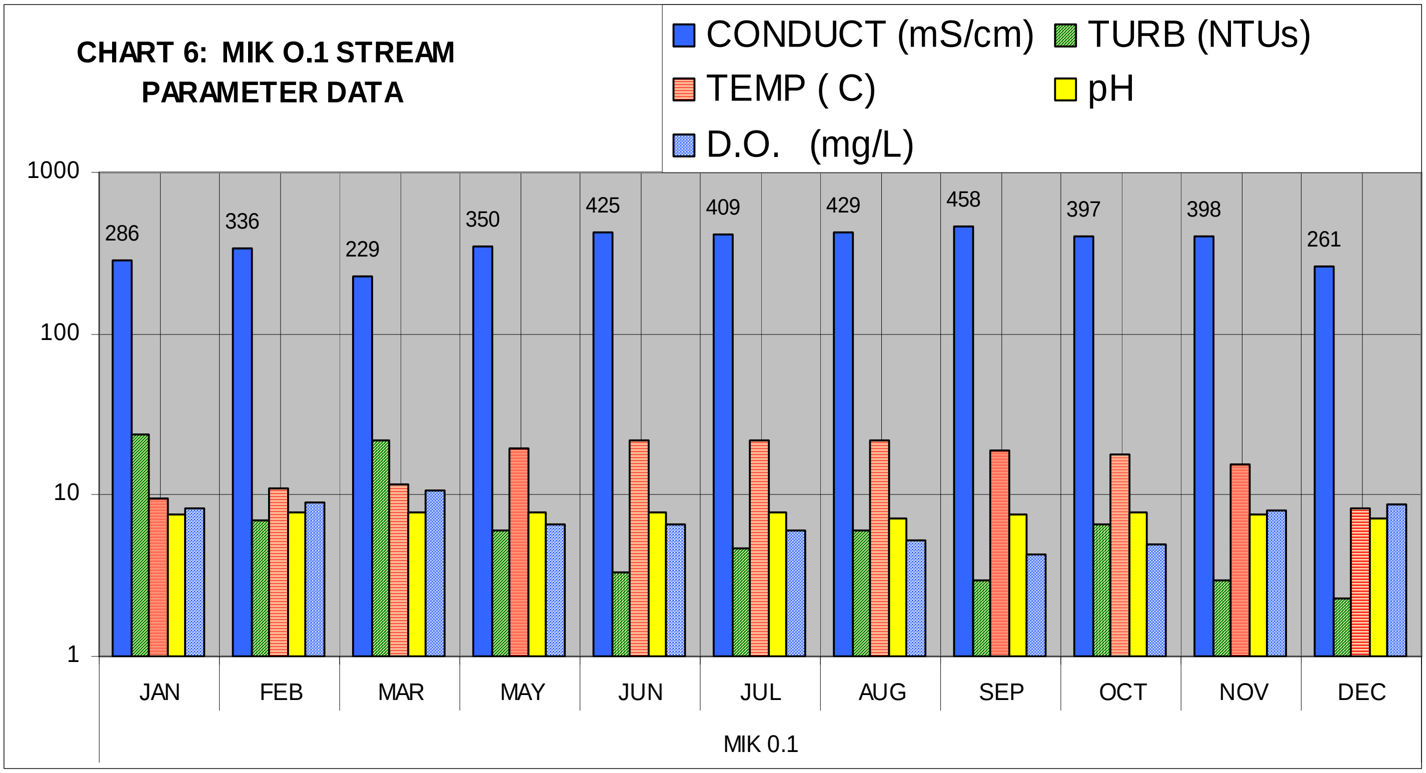


CHART 6: MIK 0.1 STREAM PARAMETER DATA
CONDUCT (mS/cm)
TURB (NTUs)
TEMP (C)
pH
D.O. (mg/L)
1000
100
10
1
286
336
229
350
425
409
429
458
397
398
261
JAN
FEB
MAR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MIK 0.1

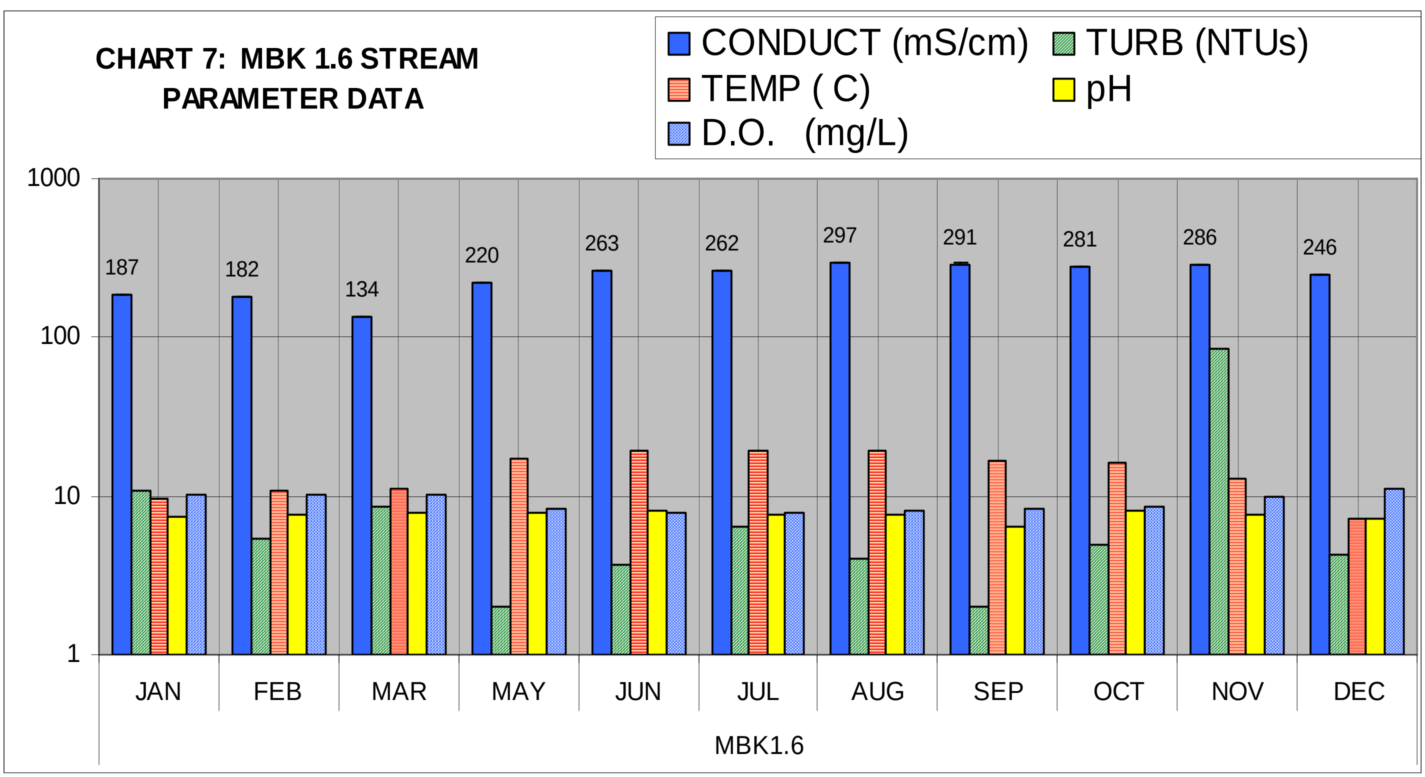


CHART 7: MBK 1.6 STREAM PARAMETER DATA
CONDUCT (mS/cm)
TURB (NTUs)
TEMP (C)
pH
D.O. (mg/L)
1000
100
10
1
187
182
134
220
263
262
297
291
281
286
246
JAN
FEB
MAR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MBK1.6

References

Horiba. November 1991. 2nd edition. *Horiba Water Quality Checker: Model U-10 Instruction Manual*. Horiba, Ltd., Miyanohigashi, Kisshoin, Minami-ku, Kyoto, Japan.

TDH. 1999. *Standard Operating Procedures.* Tennessee Department of Health Laboratory Services. Nashville, Tennessee.

Tennessee Department of Environment and Conservation. *The Status of Water Quality in Tennessee: Technical Report.* Division of Water Pollution Control, Tennessee Department of Environment and Conservation. Nashville, Tennessee. 1998.

Thomasson, D. A. 2005. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation. Department of Energy Oversight Division. Oak Ridge, Tennessee.

U.S. Environmental Protection Agency. *Environmental Compliance Standard Operating Procedures and Quality Assurance Manual*, U.S. Environmental Protection Agency, Region IV. Environmental Services Division. Atlanta, Georgia. 1991.

U.S. Environmental Protection Agency. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual,* U.S. Environmental Protection Agency, Region IV. 960 College Station Road, Athens, Georgia. 1996.

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CHAPTER 6 SURFACE WATER MONITORING

Ambient Surface Water Monitoring Program

Principle Author: John G. Peryam

Abstract

The Division conducted surface water sampling at 21 sites on the Clinch River and some tributaries of the Clinch River in 2005 (Table 1.1). The samples were analyzed for certain metals and nutrients. The data met all State water quality criteria for the parameters analyzed.

Introduction

The Division conducts semi-annual surface water sampling to detect possible contamination from DOE sites. There are eight (8) sites on the Clinch River and 13 tributary sites, Table 1.1. Contaminants in surface water samples are rarely detected; the data provide an ambient data set for evaluation of possible future contaminant discharges.

Sampling was conducted during May/June and November. Samples were analyzed for E. coli and Enterococcus bacteria, ammonia, COD, dissolved residue, NO_3 & NO_2 nitrogen, suspended residue, total hardness, total kjeldahl nitrogen, total phosphate, arsenic, cadmium, copper, iron, lead, manganese, mercury, chromium, and zinc.

Methods and Materials

Sampling was conducted using the methods described in the 2005 Ambient Surface Water Monitoring Plan. Tributary sites are sampled far enough upstream from their mouths on the Clinch River to avoid the effects of high river flows. See Figures 1.1 through 1.6. The Tennessee State Department of Health (TDH) Laboratories processed the samples, according to EPA approved methods.

Results and Discussion

The data met all State water quality criteria for the parameters analyzed.

Conclusion

The data met all State water quality criteria for the parameters analyzed.

Table 1.1 Sample Locations:

Site	Location	Clinch River Mile*	Map
1	Clinch River Mile (CRM) 78.7	78.7	Figure 1.5
2	CRM 52.6	52.6	Figure 1.4
3	CRM 35.5	35.5	Figure 1.3
4	CRM 17.9	17.9	Figure 1.2
5	CRM 10.1	10.1	Figure 1.1
6	CRM 48.7	48.7	Figure 1.4
7	CRM 41.2	41.2	Figure 1.3
8	Scarboro Creek	41.2	Figure 1.3
9	Kerr Hollow Branch	41.2	Figure 1.3
10	McCoy Branch	37.5	Figure 1.3
12	East Fork of Walker Branch	33.2	Figure 1.3
13	Bearden Creek	31.8	Figure 1.3
17	Unnamed Stream	20.0	Figure 1.2
18	Raccoon Creek	19.5	Figure 1.2
20	Grassy Creek	14.55	Figure 1.2
22	Unnamed Stream	14.45	Figure 1.2
23	Ernie's Creek	51.1	Figure 1.4
24	White Creek	102.4	Figure 1.6
25	Clear Creek	77.7	Figure 1.5
32	CRM 19.7	19.7	Figure 1.2
33	Poplar Creek Mile 1.0	12.0	Figure 1.2

*For tributaries, refers to mouth.

Figure 1.1: Sampling Sites

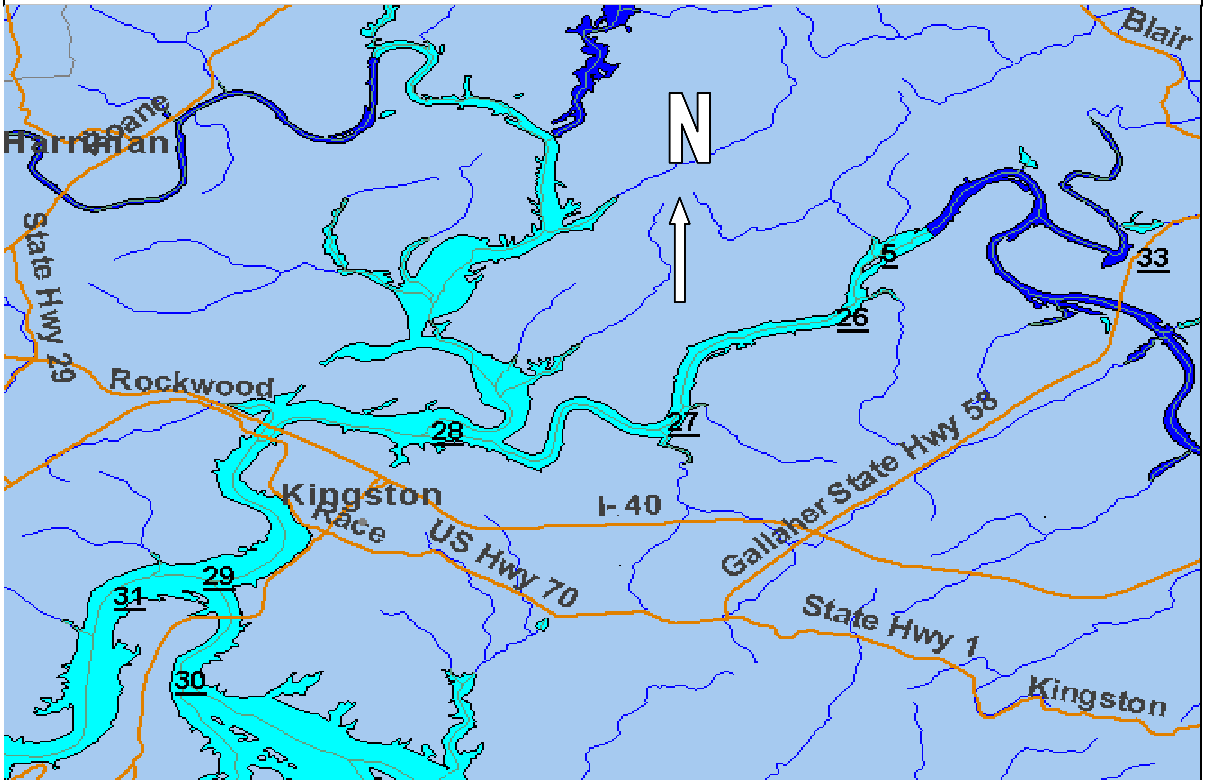


Figure1.2: Sampling Sites

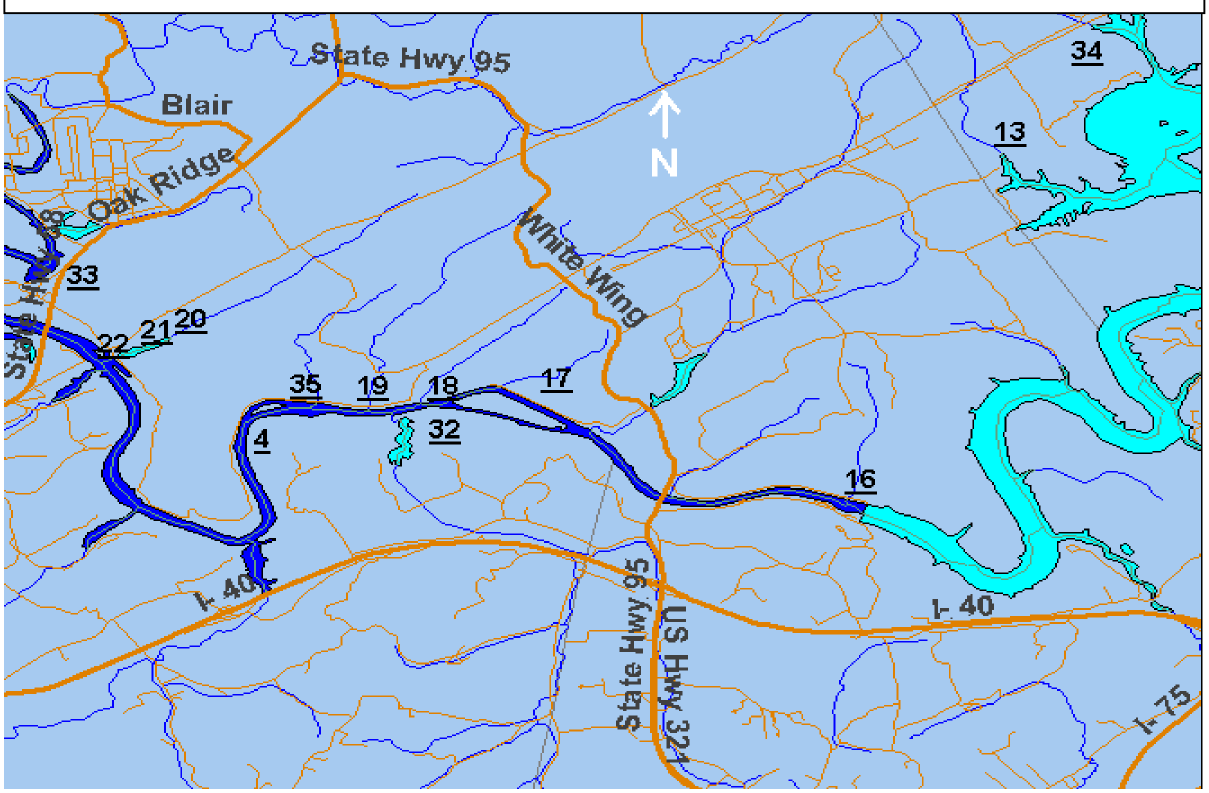


Figure 1.3: Sampling Sites

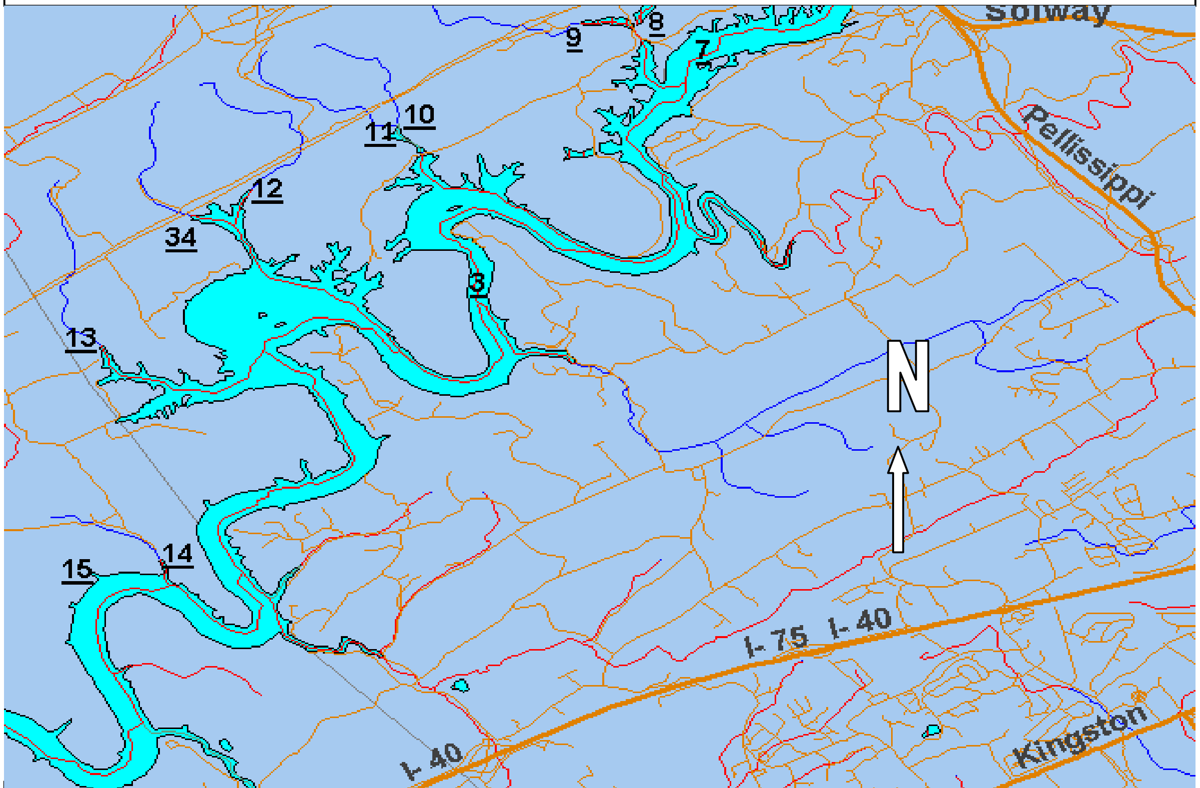


Figure 1.4: Sampling Sites

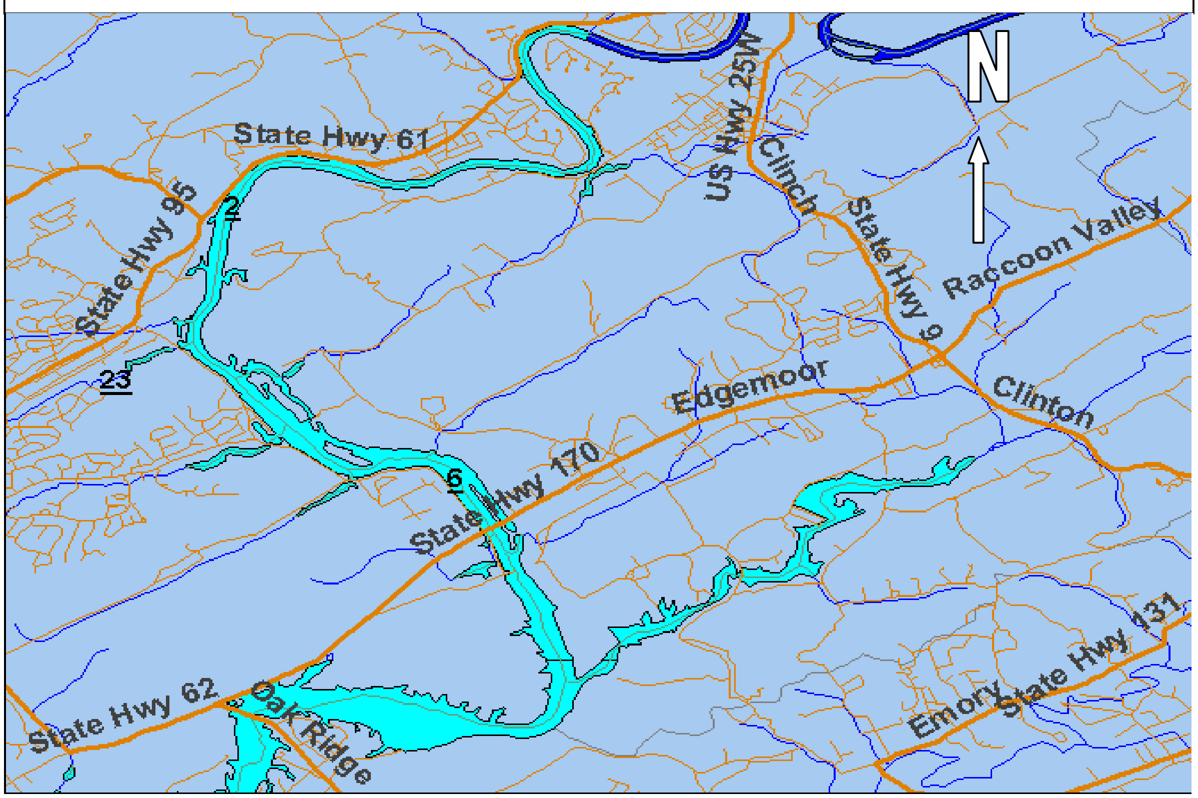


Figure 1.5: Sampling Sites

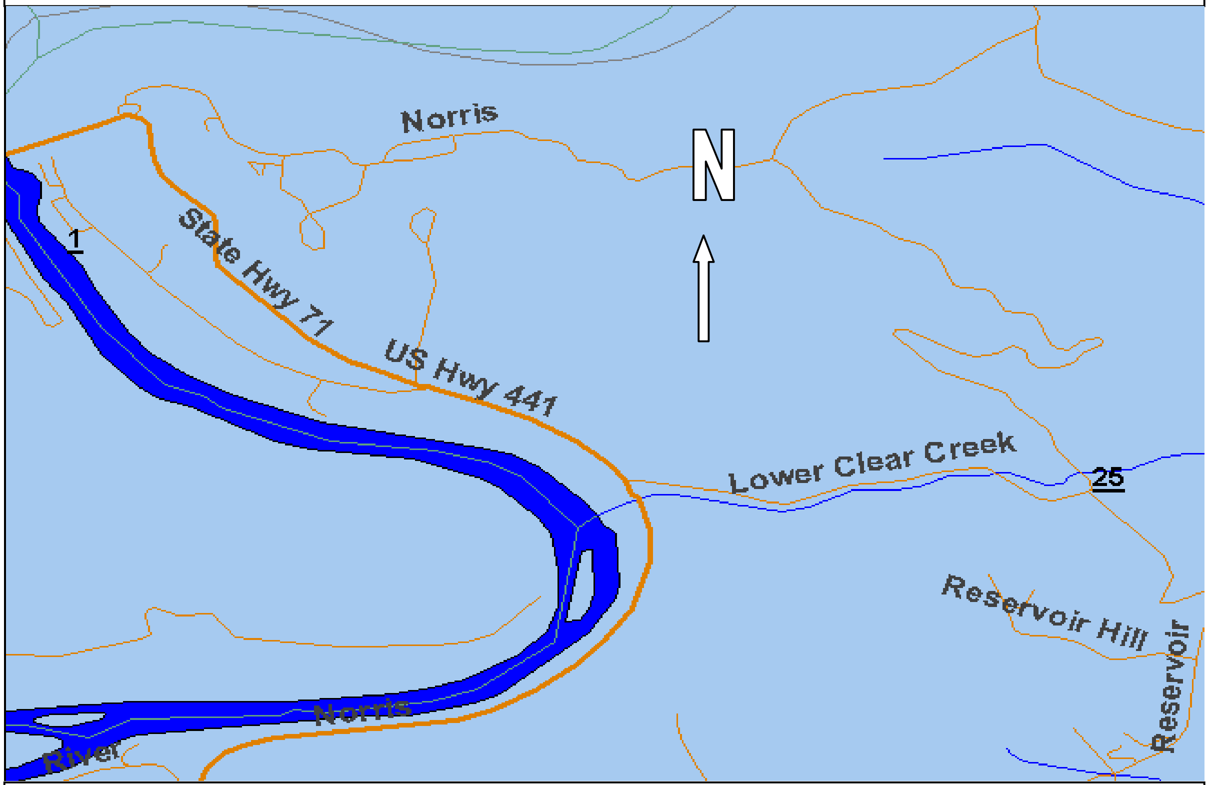
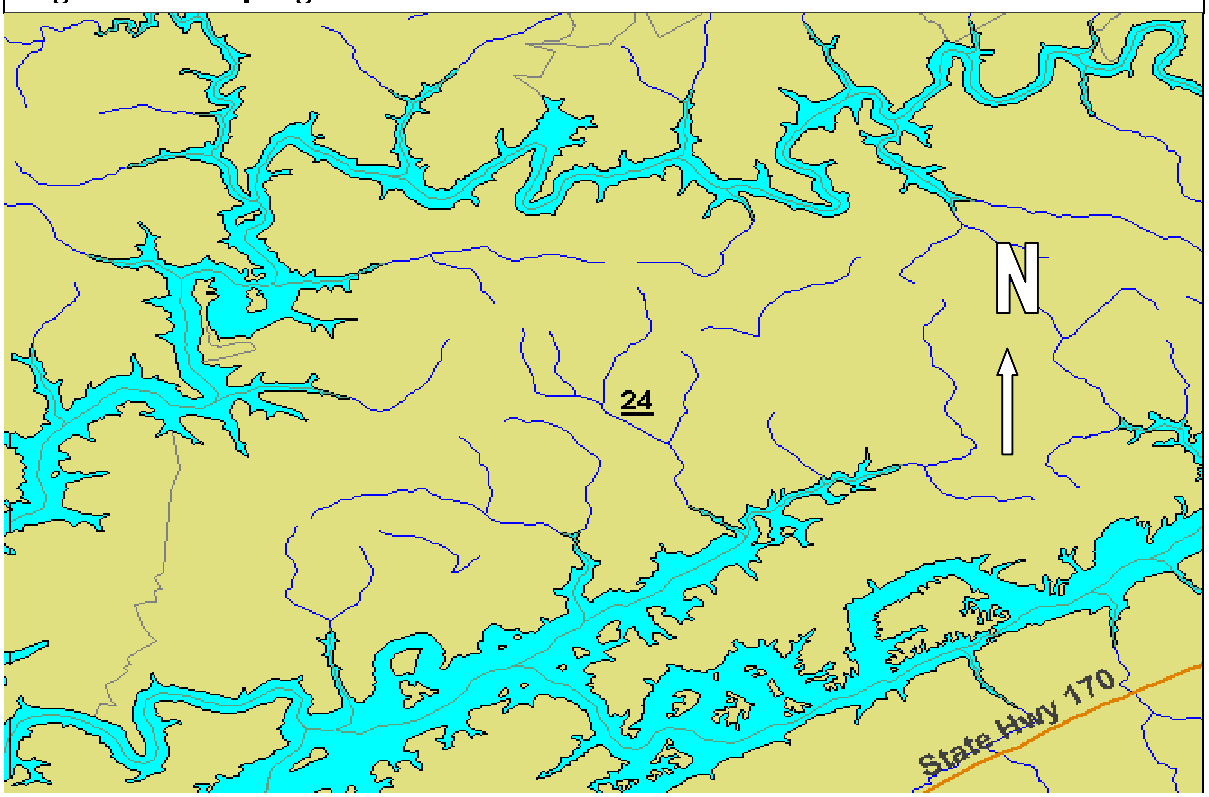


Figure 1.6: Sampling Sites



References

Tennessee Department of Environment and Conservation. 1997. *State of Tennessee Water Quality Standards, Rules of the Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3 General Water Quality Criteria, Chapter 1200-4-4 Use Classifications for Surface Waters*. Nashville, TN.

Tennessee Department of Environment and Conservation Department of Energy-Oversight. 1996. *Standard Operating Procedures.* Oak Ridge, Tennessee.

Tennessee Department of Health Laboratory Services. 1999. *Standard Operating Procedures.* Tennessee Department of Health Laboratory Services. Nashville, TN.

Tennessee Department of Environment and Conservation. 1998. *The Status of Water Quality in Tennessee: Technical Report.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, TN.

Thomasson, D. A. 2005. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

U. S. Environmental Protection Agency. Enforcement and Investigations Branch. Region 4. 1997. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM).* Athens, Georgia.